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A REVIEW OF THE INSECTICIDAL USES OF ROTENONE AND ROTENOIDS FROM DERRIS, LONCHOCARPUS (CUBE AND TIMBO), TEPHROSIA, AND RELATED PLANTS

PART IX: DIPTERA

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INTRODUCTION

This is the ninth in a series of papers designed to review all available information on the insecticidal uses of rotenone and the rotenoids. Parts I to VIII have reviewed tests with derris, cube, timbo, Tephrosia, Mundulea, and their constituents on members of the Collembola, Orthoptera, Dermaptera, Odonata, Isoptera, Corrodentia, Mallophaga, Thysanoptera, Homoptera, Hemiptera, Anoplura, Coleoptera, Lepidoptera, and Hymenoptera. Apparently no tests with the rotenone plants on Thysanura, Ephemeroptera, or Plecoptera have been recorded. Part IX, the present paper, reviews the tests that have been made on Diptera.

DIPTERA

Agromyzidae

Agromyza phaseoli Coq. (= Melanagromyza phaseoli Coq.), bean fly; French bean miner

Mathieu (201) in 1920 reported the control of this species attacking young beans, with derris.

> A trial of tuba was made on a field of 8 beds, 66 feet long, with 1,056 seeds of lima bean (Small Sieva) on October 28, 1919. Ten ounces of tuba root were well pounded in a wooden mortar, the juice was thoroughly expressed, and the fiber exhausted in 20 imperial gallons of water. Tuba water was then applied to each young plant at the rate of a cigarette tin full to 4 plants, morning and evening, for 15 days, until the plants were sufficiently established to be past all danger, which is only present during the first stage of their existence, when the stem is tender. Only 16 seeds failed to germinate, and of the 1,040 plants that came up, not one has died. Today the plot is showing the most vigorous growth, a living testimony to the potency of the tuba-root as a plant-insect killer.

Van der Goot (120) in 1930 reported that sprinkling the necks of the roots of plants of katjang djogo and kratok with a 3 percent derris extract was valueless for control in Java.

Van der Vecht (302) of Buitenzorg, Java, in 1936 reported that derris was ineffective.

Morgan (207) in 1938 reported that a contact spray consisting of 1 pound of derris root (3.5 percent rotenone) and 3 pounds of soft soap to 50 imperial gallons of water destroyed the adults in laboratory tests, but in field practice, using a knapsack pump, it was difficult to hit enough flies to give appreciable control.

Agromyza pusilla Meig.

F. F. Smith (253) in 1939 wrote that this serpentine leaf miner on Gerbera jamesoni Bolus. was being combated by picking and destroying the infested leaves, or by spraying by derris or nicotine extracts.

(Agromyza) Liriomyza solani Macq.

A spray of derris powder with soft soap was ineffective in preventing attack by the tomato leaf miner, "Phytomyza solani (Macq.)," according to the Experimental and Research Station, Cheshunt, Herts, England (80), in 1938. [This species is also referred to by English authors as "Agromyza (Liriomyza) solani. Cf. Rev. Applied Ent. (A) 25: 668.]

Phytomyza ilicis (Curtis), the holly leaf miner

Langford and Cory (168) in 1937 reported that sprays containing a mixture of 3 pounds of 4 percent rotenone powder and 3 pounds of rosin emulsion per 100 gallons of water did not kill the larvae within the mines.

Anthomyiidae

Atherigona indica Mall.

The Tanganyika Territory Department of Agriculture (270) in 1935 reported that the application of derris preparations gave almost complete control of the sorghum stem maggot at an economic cost.

Hylemya antiqua Meig., the onion maggot

Smith and Wadsworth (255) in 1921 tested insecticides against onion flies. Six applications of derris-soot mixture (2 parts soot and 1 part derris) at the rate of 1 ounce per square yard gave 60 percent of clean onions, whereas soot alone gave only 16 percent.

Brittain (42) in 1925 reported that mature larvae were immersed for 5 seconds in a suspension of derris root (3 lb. to 100 imp. gal.) and then placed upon their food plant. The mortalities from different treatments were as follows:

Age of maggot (days)	Mortality from	
	Bichloride of mercury, 1:1,000 solution	Derris, 3 lb. in 100 imp. gal. of water
	Percent	Percent
1	100	100
4	100	100
7	100	100
10	75	35
15	50	25
Ready to pupate	20	0

K. M. Smith (254) in 1925 reported on tests made with various insecticides. A mixture of 1 ounce of derris with 2 ounces of soot per square yard did not give results promising enough to justify further trials.

The Ohio Agricultural Experiment Station (224) in 1936 reported that derris powder (4 percent rotenone) in water at 4 pounds to 100 gallons permitted 18 percent of the eggs to hatch. Mercuric chloride, 1 ounce to 8 gallons of water, and diphenylene oxide 1: 40 in oil, killed all eggs.

Hylemya brassicae (Bouché), the cabbage maggot

Brittain (40) in 1921 described experiments in which a 50:50 mixture of derris with clay and also with derris solution at two strengths (1.5 and 3 lb. to 100 imp. gal.) were applied to cabbage for control. The clay-derris mixture was applied at the rate of 960 pounds per acre, the derris solutions at the rate of 10 and 20 pounds of derris with 650 imperial gallons of water per acre. All the derris treatments protected the plants. Pure derris powder applied to cabbage destroyed 4 percent of the plants in 2 tests. Derris (3 lb. to 100 imp. gal.) poured about plants previously infested with 25 fully grown larvae of the first brood failed to prevent any from pupating.

Brittain (41) in 1922 reported that when derris (3 lb. to 100 imp. gal. of water) was applied to cabbage (Copenhagen Market) 39 percent of the plants were destroyed by maggots. In another tests with Early Jersey Wakefield, 2 pounds of derris to 100 imperial gallons of water permitted about 29 percent of the plants to be destroyed. Tests with 3 pounds of derris to 100 imperial gallons permitted from 45 to 80 percent of the Early Jersey Wakefield to be destroyed. On radishes, derris (3 lb. to 100 imp. gal.) permitted 71 percent of the plants to

be infested. Corrosive sublimate was the only treatment that gave satisfactory control. Only one material, derris, proved very ineffective. As it was from the same lot of material that was used the previous year with fair results, Brittain assumed that it had deteriorated in storage. About two-fifths of a pint of liquid and five-ninths of an ounce of dust was applied per plant. In 1925 Brittain (42) reported that mature larvae immersed for 5 seconds in a suspension of derris root (3 lb. to 100 imp. gal.) and then placed upon their food plant were unaffected, whereas a 1: 1,000 solution of mercuric chloride killed 10 percent.

K. F. Smith (254) in 1925 reported that a mixture of 1 ounce of derris with 2 ounces of soot per square yard did not give results promising enough to justify further trials.

Turner (277) in 1932 reported that in 1931 rotenone extracted from cube was tested for control. Early cabbages and two series of treatments were used in the tests. One series was treated once, on May 1; the other twice, on May 1 and May 15. Rotenone was used in three dilutions, and was applied in an acetone-water suspension, 1/2 cupful being poured around the base of each plant. Heads were harvested on July 8 and July 14, and yields were compared with those obtained by the use of bichloride of mercury. These figures show that rotenone at the rate of 1: 2,500 and 1: 5,000, even in a single treatment, increased the yield of cabbage, as compared with the yield of check plots. Rotenone at 1: 10,000 was not so effective. The percentage of heads maturing in check plots was 72, and on the rotenone plots from 70 to 100. Comparison with results obtained with bichloride of mercury shows that rotenone was approximately as effective only when used twice at a dilution of 1: 2,500. Because of the small size of the rotenone plots these results cannot be accepted as final; however, it is evident that rotenone has some value in control.

Benkert and Company (25) in 1934 wrote that for the root maggot attacking cabbage derris dust should be applied around the stalk as soon as the eggs are found.

Pegomya hyoscyani (Panz.), the spinach leaf miner

Jancke (150) in 1931 reported that in experiments with the beet fly, a mortality of 80 percent was attained for 4 days with concentrations of Polvosol of 1 percent and 1 p.p.m. These results suggest that the spray would be of value against the cherry fly (Rhagoletis cerasi (L.)).

Pegomya nigritarsus (Fall.)

According to Etablissements Rotenia in 1938, in a letter to R. C. Roark, this pest on begonia was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root and 88 percent of talcum.

Calliphoridae

Calliphora erythrocephala Meig.

This species was tested by the immersion technique of Craufurd-Benson (64), as reported in 1938, and has given some interesting and reliable information, although the results were not so accurate as those of other workers who used the spraying method.

Calliphora sp.

Wilbaux (321) in 1934 tested extracts of the leaves of Tephrosia vogelii that were 22 years old and reported that as a contact insecticide the leaves are about as toxic as nicotine. Larvae of Calliphora sp. were perfectly resistant, even to sprays containing 1 part of T. vogelii to 200 of dry vegetable matter, Pupation took place more rapidly, but all the pupae hatched.

Cochliomyia macellaria F., the secondary screwworm

Parman et al. (225) and also Roark et al. (242) in 1927 reported results of chemotronic tests. A commerical derris powder repelled 95 percent of the flies visiting a bait of beefliver. This is about the same percentage as that obtained with pyrethrum powder. When diluted with 9 parts of kaolin it repelled 38 percent.

Cochliomyia americana C. & P., the screwworm

In 1928 Parman et al. (226) reported that derris powder (0.5 gm. plus kaolin 4.5 gm.), spread upon 4-ounce cubes of beef liver in a mason jar, repelled 38 percent of the flies that approached the meat.

E. W. Laake, in a typewritten report to the Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in 1935, reported results of field tests by McGovran and Ellisor of repellents for wound-infesting flies on sheep and goats at Valdosta, Ga. Rotenone, derris resin, and derris root mixed with pine-tar oil and benzene seemed to be the most promising mixtures. The following mixtures were tested with excellent results:

Pine-tar oil 75 parts, benzene 24 parts, rotenone 1 part.

Pine-tar oil 75 parts, benzene 24 parts, derris resin 1 part.

Pine-tar oil 75 parts, benzene 20 parts, derris root 5 parts.

The following were found to be unsatisfactory as repellents: A mixture of pine-tar oil 70 parts, sulfonated castor oil

parts, and ground derris root 5 parts; ground derris root applied as a powder. This did not adhere well to dry parts of the wound.

Laboratory tests of larvicides for mature larvae were made. A mixture of benzene 95 parts and derris root 5 parts gave 100 percent control of emergence, whereas benzene alone gave 62 percent control. Rotenone, pyrethrum extract, and derris resin in benzene also gave better control than bezene alone. The following were tried as larvicides in the laboratory:

Benzene 95 parts, derris root 5 parts.

Benzene 99 parts, rotenone 1 part.

Benzene 99 parts, derris resin 1 part.

Benzene 74 parts, carbon tetrachloride 25 parts, rotenone 1 part.

Benzene 70 parts, carbon tetrachloride 25 parts, derris 5 parts.

Benzene 74 parts, carbon tetrachloride 25 parts, derris resin 1 part.

Rotenone and ground derris root markedly increased the toxicity of mixtures of benzene and carbon tetrachloride. Pyrethrum extract and derris resin also increased the toxicity of these mixtures.

R. Melvin, in a similar typewritten report in 1935, stated that he treated artificially wounded rabbits and guinea pigs infested with Cochliomyia americana with various chemicals, 5 cc. or 1 gm. per treatment. An acetone solution of rotenone (1 percent) killed half the larvae in the wound but also killed the guinea pig. Dry rotenone in 2 tests killed all the larvae in 2 guinea pigs without affecting the pigs. Pyrocene, a proprietary product containing 0.73 percent of rotenone in pine oil with an emulsifying agent, proved to be a poor larvicide but a good repellent of the larvae. Pyrocene was tested on 13 guinea pigs and 2 rabbits, causing the larvae to leave the wounds, but killing only a few. The animals were unaffected by Pyrocene. Of 20 grown larvae dipped in an acetone solution of rotenone (1 percent) 19 survived. In 1935 Melvin stated, in another report to the Division, that Pyrocene added to artificially infested wounds on guinea pigs caused larvae to leave the wounds and the animal was unaffected. Rotenone in acetone (1 percent) killed from one-third to one-half of the larvae. Rotenone crystals killed all the larvae without injuring the animal. Rotenone in acetone (1 percent) also killed all eggs dipped momentarily into it. Over 1,000 eggs less than 3 hours old were used with each test chemical. Eagleson reported that the following mixtures containing rotenone gave promising results as a fly spray: (A) Rotenone extract, 0.25 percent; camphor byproduct, 3.3 percent; kerosene, 96.4 percent.

This spray gave 65 percent of paresis in 2-cc. doses and 100 percent mortality in 3-cc. doses. (B) Rotenone extract, 1 percent; General Naval Stores Pine Oil No. 2, 99 percent. Two cc. of this spray gave 100 percent mortality.

Laake, of the Valdosta, Ga., laboratory of the same Division, in a typewritten report for the second quarter of 1936, reported tests with derris products as larvicides applied to wounds in infested goats. The following mixture killed all larvae: Benzene 40 percent, carbon tetrachloride 30 percent, acetone 25 percent, derris resins 5 percent. The following mixtures gave excellent control: Benzene 55 percent, carbon tetrachloride 30 percent, acetone 12.5 percent, derris resins 2.5 percent; benzol 64 percent, carbon tetrachloride 30 percent, acetone 5 percent, derris resins 1 percent; and soluble pine oil 85 percent, acetone 10 percent, derris resins 5 percent.

In immersion tests in the laboratory with mature larvae the following gave 100 percent control: Carbon tetrachloride containing 5, 10, or 15 percent of devils-shoestrings; benzene containing 5 or 20 percent of devil's-shoestrings; and benzene 30 percent, carbon tetrachloride 23 percent, acetone 27 percent, derris resins 10 percent. Mixtures of furfural 83 percent and derris rosins 17 percent killed 96 to 98 percent of the larvae. The following mixtures of pine-tar oil, acetone, and derris resins, in the percentages given, respectively, when applied to the clipped skin and wounds in goats did not cause injury: 70.0: 25: 5: 72.5: 25: 2.5: 74: 25: 1; 85: 10: 5: 87.5: 10: 2.5: 89: 10: 1: and pine-tar oil 85 percent plus devils'-shoestrings 15 percent.

Laake, in a similar report in 1936, stated that of preparations tested as repellents, pine-tar oil to which had been added ground derris root, rotenone, or derris resins seemed to be the most promising mixtures. Of larvicides tested in the field at Valdosta, Ga., mixtures of benzol, acetone, carbon tetrachloride, and 2.5 or 5.0 percent of derris resins gave good control. A mixture of benzol and carbon tetrachloride containing 10 percent of ground derris root gave good control. In this mixture most of the derris root did not go into solution but settled to the bottom of the container. Materials found highly toxic to flies when applied as sprays were Lethane, rotenone, and pyrethrum extract.

McGovran (192) reported in 1936 that in preliminary field tests at Valdosta a mixture of pine-tar oil 85 percent, acetone 10 percent, and derris resins 5 percent was more repellent to the flies than pine-tar oil alone.

McGovran and Ellisor, in a typewritten report to the Division in 1936, stated that the action of chemicals was tested in infested artificial wounds on goats. Approximately 10 cc. of each larvicide was applied to the infested wound and the animal was held in such a position that the larvicide was in contact with the larvae 2 minutes. A cotton plug was inserted in the wounds treated with benzol. The other treated and check wounds were left open. The following data were obtained from larvicide tests during January and February. The materials that killed 100 percent of the larvae were as follows: Benzol 65 percent, carbon tetrachloride 25 percent, ground derris root 10 percent (results of 3 tests); benzol 67.5 percent, carbon tetrachloride 25 percent, ground derris root 7.5 percent (1 test); benzol 70 percent, carbon tetrachloride 25 percent, ground derris root 5 percent (1 test); clear extract of benzol 70 percent, carbon tetrachloride 25 percent, ground derris root 5 percent (1 test); and clear extract of benzol 65 percent, carbon tetrachloride 25 percent, ground derris root 10 percent (1 test). Mature larvae were dipped for 30 seconds into a mixture of 90 percent of carbon tetrachloride and 10 percent of derris root. The ground derris root was allowed to remain in the carbon tetrachloride for 4 days, then all the material not in solution was filtered off. This treatment killed two-thirds of the larvae.

Melvin, in 1936, in a typewritten report to the Division, described additional laboratory tests on artificially infested wounds on guinea pigs in Texas. Pyrocene and mixtures of pyrocene and water containing 80, 60, 40, and 20 percent of pyrocene not only killed many larvae but also caused larvae to leave the wounds. Rotenone crystals killed all the larvae in the wounds without affecting the guinea pig. Rotenone (0.5 or 1.0 percent) in General Naval Stores Pine Oil No. 2 was highly effective. Pyrocene 60 percent and 80 percent with water killed 62 percent and 39 percent, respectively, of larvae dipped into it. In a similar typewritten report later in that year, he said that rotenone powder killed 100 percent of the larvae in wounds. Phenothiazine was regarded as the most promising larvicide for application to wounds.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (290), in 1936 reported that in the work of developing more effective larvicides and repellents over 200 different chemicals and mixtures were tested. Among the many materials tried as larvicides that gave promising results was a mixture of benzol and carbon tetrachloride, containing 10 percent of ground derris root. In small-scale tests ground derris root, rotenone, or derris resins added to pine-tar oil appeared to be more effective as a fly repellent than pine-tar oil alone.

Bushland (47) in 1940 reported that the minimum lethal concentration of rotenone to young larvae was between 0.05 and 0.08

percent of the beef medium on which they fed.

Lucilia cuprina (Wied.)

Lennox (178) in 1940 wrote on the action of stomach larvicides on this species. The toxicity of a number of compounds was measured by (A) growth retardation and (B) rate of action. Derris extract was toxic at concentrations of 0.1 and 0.01 percent.

Lucilia sericata (Meig.)

Laake et al. (165) in 1931 reported the results of tests of materials as attractants or repellents to this greenbottle fly. Beef-liver bait 4 ounces, to which 5 gm. of derris powder was added, attracted only 40 percent as many as did untreated bait. A mixture of 1 part of derris powder and 9 parts of kaolin attracted 20 percent.

Baudet and Nieschulz (23) in 1933 reported that derris powder containing 2 percent of rotenone was entirely inert toward the larvae. Four-day-old larvae crawled around in the derris powder for 3 hours without suffering any ill effects. A suspension of derris powder in soap and water was also without effect on the mobility of larvae submitted to the influence of this suspension for a 5-minute period. Pine oil was found to be toxic to the larvae. The addition of rotenone to pine oil in quantities of 0.1 to 10 percent did not increase the toxicity of the pine oil. It was concluded that derris powder and rotenone are inactive toward the larvae.

According to Van der Laan (166) in 1936, this species is not affected by derris.

Hoskins et al. (143) in 1940 reported that rotenone mixed with a synthetic diet in which larvae of this species were placed was toxic at the following concentrations:

Concentration	Mortality	Stage of Insect
	Percent	
1/128 percent	100	Second and third instars.
1/256 percent	98	Second and third instars; pupae.
1/512 percent	62	Second, third and fourth instars.

Lucilia sp.

Parman et al. (206) in 1928 reported that derris powder 0.5 gm. plus kaolin 4.5 gm., spread upon 4-ounce cubes of beef liver in a mason jar, repelled 81 percent of the flies that approached

the meat.

Phormia regina (Meig.)

Haag (129) in 1931 reported that maggots of the black blow-fly that had been given food sprinkled with rotenone crystals developed identically with the control maggots.

Breakey and Miller (38) in 1935 reported the results of tests with rotenone sprays prepared from an extract of derris in pine oil assaying 5 gm. of rotenone for each 100 cc. Emulsions were made from this stock containing 1 part of rotenone, 19 parts of pine oil, 5 parts of saponin, and 75 parts of water. Dilutions made from these emulsions gave the desired concentrations of rotenone. One part of rotenone in 5,000 parts of the spray killed about 98 percent of the eggs.

Phormia sp.

Melvin, in 1936, in a typewritten report to the Division of Insects Affecting Man and Animals, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, stated that when grown larvae of Phormia were dipped in a 1-percent solution of rotenone in acetone, 84 percent emerged.

Chironomidae

Chironomus brachialis Coq.
C. cingulatus Meig.
C. decorus Joh.
C. lobiferus Say
C. nervosus Staeg.
C. sp. near nervosus Staeg.
C. sp. near paganus Meig.

See Fellton (85) under Chironomus tenuicaudatus Mall., p.11 .

Chironomus plumosus (L.) var. prasinus Meig.

An anonymous writer (6) in 1937 stated that derris was ineffective.

Chironomus tenuicaudatus Mall.
C. sp. near tenuicaudatus Mall.

Fellton (85) in 1940 reported on the control of aquatic midges. In the laboratory derris powder(5 percent rotenone) at 12 parts per million killed only 28 percent of Procladius larvae, whereas an emulsion of 80 parts of orthodichlorobenzene

and 20 parts of sulfonated castor oil at 9.6 parts per million gave a mortality of 100 percent after 72 hours. For the control of these midges in the two fresh-water lakes at the New York World's Fair, derris was used, starting in April 1939. In conjunction with each derris application, copper sulfate was dissolved in the lakes at the rate of 1 part per million in order to kill most of the algae therein, which served as a source of food and shelter for the larvae and to increase the potency of the derris by reducing the alkalinity of the lake water. Spraying was started on April 10, when the water temperature reached 50° F. and the overwintering larvae started to show signs of activity. Sufficient derris of 5 percent rotenone content was applied to build up a concentration of 6 parts per million (a dilution of 0.00003 percent rotenone) in Willow Lake and a concentration of 10 parts per million (a dilution of 0.00005 percent rotenone) in Fountain Lake. The results were very striking, particularly in Fountain Lake. Many dead or dying bloodworms were soon observed floating on the water, thousands of others were washed ashore, and the lake bottom was covered with the dead and decomposing bodies of the larvae. Thereafter the interval between treatments was based on the life cycle of the species involved. The control operations were extremely effective against Chironomus lobiferus, C. cingulatus, and the C. tenuicaudatus group of small green midges. These had been the dominant species during the summer and fall of 1938. The other Chironomus species and the Tanytarsus were also very definitely under control.

The species present were: Chironominae -- Chironomus lobiferus, C. cingulatus, C. tenuicaudatus, C. sp. near tenuicaudatus, C. brachialis Coq., C. nervosus, C. sp. near nervosus, C. sp. near paganus, C. decorus, Tanytarsus eminulus (Walk.), and (Tanypodinae) Procladius culiciformis (L.), P. choreus (Meig.), and Tanypus puntipennis Meig. Derris was not so toxic to Procladius as to Chironomus larvae; however, the number of Procladius adults that emerged was kept down very considerably by measures directed against the pupae. The active pupae tended to congregate in great numbers in protected places on the lee shore of the lakes and could be killed there by spraying with derris or with the pyrethrum-kerosene emulsion that was used for the control of mosquito breeding.

Chironomus sp.

Buchmann (45) in 1932 described tests with finely powdered derris powder against larvae. Strewed upon water at the rates of 50, 25, 12, and 6 mg. per liter, it killed all within 24 hours. A piece of derris root put in a breeding glass containing larvae killed them in 6 to 8 hours. An aqueous extract of the root acted similarly.

DeBussy et al. (48) in 1936 reported that derris in water at 1:1,000 (rotenone 1:14,000) killed larvae.

Procladius culiciformis (L.)
P. choreus (Meig.)
Tanypus puntipennis Meig.
Tanytarsus eminulus (Walk.)

See also Fellton (85) under Chironomus tenuicaudatus Mall., on page 11.

Chloropidae

Chloropisca notata (Zett.) (= circumdata (Meig.))

DeBussy et al. (48) in 1936 reported that dusting with derris was ineffective against full-grown flies, but spraying with derris powder suspended in water (rotenone 1:3,000) was more successful, although not entirely satisfactory.

Nozu (221) in 1939 reported that spraying with nicotine sulfate kills the larvae in the leaves, and derris insecticides are also effective.

Oscinis oryzella Mats.

Oguro and Kimura (223) in 1932 recommended a proprietary derris preparation for control, which is very injurious to rice in Japan.

Culicidae

Aedes aegypti (L.), the yellow-fever mosquito

The Zanzibar Public Health Department (329) in 1917 tested Tephrosia vogelii as an insecticide. The fresh green leaves were pounded in a mortar and made into a pulp. Six half-grown larvae were put in a 1-percent solution of this pulp in water. All were dead in 12 hours.

Aedes excrucians (Walk.)
A. fitchii (F. & Y.)
A. stimulans (Walk.)
A. trichurus Dyar (= A. cinereoborealis (F. & Y.))

Gibson (108) in 1929 reported further on derris for mosquito control in Canada. Like pyrethrum, derris when used in dust form is readily carried away by the wind. The field results from the use of this material were even less satisfactory than those from pyrethrum. A large semipermanent pool in open country containing a heavy infestation of mature larvae and some pupae of these four species was dusted with derris at the rate of 5 pounds per acre. At the end of 18 hours many larvae appeared

sluggish and lacked control of their movements. In 48 hours there had been a marked reduction in the numbers. At the end of 72 hours the reduction in the infestation as compared with check pools was notable, the visible larvae also appearing rather inactive. In 5 days from the time of applying the derris, however, many larvae and pupae were still present and active, and adults were emerging. The dusting reduced the infestation materially but not enough to compare favorably with the effect of oil.

Aedes vexans (Meig.) (= A. sylvestris (Theob.))

See Ginsburg et al. (112, 113) under Culex pipiens L., on page 18.

Gibson (106) in 1927 reported that powdered derris root has lethal properties when used against culicine mosquito larvae. When dusted on the surface of water containing larvae of this species this material, either alone or in combination with an inert filler, destroyed the larvae in a few hours, even when used at the rate of only 2 or 3 pounds of derris to the acre. Gibson (108) in 1929 reported that pools on the edge of scrubby woodland and heavily infested with mature larvae were dusted with derris, 8 pounds to the acre. After 18 hours the larvae appeared to be as numerous as ever, and a considerable proportion were pupating. In 48 hours most of them had pupated and oil was applied to prevent a possible general emergence. The derris used in 1928 was not that used in 1927, but both samples worked equally well in the laboratory.

Twinn (279) in 1927 reported on mosquito control at Ottawa, Ontario, Canada. The derris was dusted on the water surface at the rate of approximately 3 pounds per acre. The larvae died within periods ranging from 45 minutes to more than 7 hours. They became very feeble before death, lying motionless and parallel with the surface of the water, moving with difficulty when rudely disturbed. The pupae died more slowly than the larvae, sometimes requiring more than 24 hours. Near Montreal tests were also made on a shallow pool about 200 feet square, with a grass-grown bottom, and containing large numbers of larvae of Aedes vexans. A mixture of derris and French chalk (1 to 4) was dusted just before sundown on the surface of the water by means of a small hand dust gun, at the rate of 1.5 pounds of derris to the acre. The material settled well, forming a very satisfactory film of dust over the entire surface. When examined 16 hours later, a considerable proportion of the larvae were dead and many of the living revealed the effect of the derris in their sluggish movements. The pool was not examined again until 60 hours after treatment, when all the larvae were dead, many floating on the surface of the water.

Aedes sp.

Gibson (107) in 1928 reported that under laboratory conditions powdered derris root dusted on the surface of water in shallow trays at the rate of 15 pounds to the acre of water surface destroyed larvae in 3 to 22 hours and pupae in from 2 to 5 days. In a discussion following the reading of this paper Ginsburg said: "Last summer [1927] we tested out cube root, which is a very strong fish poison. It killed fish in pools within 15 minutes but it didn't kill mosquito larvae for 24 hours, and then only a small percentage of them. The same material killed larvae in the laboratory within a few hours."

Anopheles annularis V. d. Wulp.

Wats and Singh (308) in 1937 tested extracts of Derris elliptica Benth., D. scandens Benth., and D. uliginosa Benth. against mosquitoes. Various plants were extracted with alcohol, ether, chloroform, or kerosene, and likewise tested; the method of Sinton and Wats (Rec. Malaria Survey India 5 (3): 275. 1935) was used. Anopheles annularis or A. subpictus Grassi was used for the test insect. One cc. of the undiluted test solution was sprayed into the test chamber with a No. 15 De Vilbiss sprayer. Twenty-five mosquitoes were introduced into the chamber and collected after 30 minutes' exposure. These insects were then put into a mosquito cage and placed in a dark room for 24 hours under the same conditions as a number of control insects. The results were read immediately after collection to note the number of insects flying, and after 24 hours to record the numbers dead and moribund. The results in all cases were much inferior to those with the standard mosquitocide (1 cc. of 1-percent solution of pyrocide 20 in kerosene). A crystalline substance, m.p. 274-275° C., isolated from Derris scandens, was also tested. A 40-percent solution of an ethereal extract, sprayed into the test chamber before and after introduction of the mosquitoes, gave a mortality of only about 60 percent. The ether-soluble parts of derris (containing 5 percent rotenone) obtained from a reliable American firm was similarly tested but found to be no better.

Anopheles hyrcanus var. sinensis (Wied.)

West and Russell (315) in 1932 reported experiments with various toxic substances partially absorbed on charcoal as a larvicide for anopheline mosquitoes. Rotenone, adsorbed 0.4 percent on charcoal, was tested on third and fourth instars of this species and of Anopheles subpictus Grassi. A mortality of 34 percent was obtained at the end of 24 hours. The authors concluded that rotenone on charcoal does not have any greater potency than paris green, which is less expensive.

Anopheles maculipennis Meig.

Roman and Netien (243) in 1939 reported tests with derris powder and rotenone on mosquito larvae: Anopheles maculipennis Meig., Culex hortensis Fic., and Culex pipiens L. The powders were scattered, without moistening, over the surface of the water containing the larvae. Rotenone is especially toxic when ingested by larvae.

Anopheles pseudopunctipennis Theob.

Wille et al. (322) in 1937 reported that in preliminary tests cube root containing 5 percent of rotenone had no effect on the larvae after 15 hours when used at a concentration that killed fish in 30 minutes.

Anopheles subpictus Grassi

See Wats and Singh (308) under Anopheles annularis V. d. Wulp. on page 15, and West and Russell (315) under A. hyrcanus var. sinensis (Wied.) on page 15.

Anopheles sp.

Strickland (265) in 1913 reported that derris was being tried for killing anopheline larvae in Malaya.

West and Russell (314) in 1932 reported the results of tests of larvicides for anopheline mosquitoes in the Philippines. The action of mixtures of paris green with various materials partly adsorbed on charcoal were tested on mosquito larvae. Paris green, 0.2-percent concentration, with rotenone hydrobromide, 0.4-percent concentration, killed 76 percent of the larvae at the end of 24 hours. A mixture of 0.05 percent of paris green, 0.1 percent of arsenic trioxide, 0.1 percent of derris root, and 0.3 percent of borax killed 22 percent of the larvae, and a mixture of 0.05 percent of paris green, 0.1 percent of arsenic trioxide, 0.2 percent of derris root, and 0.3 percent of borax killed 84 percent of the larvae, at the end of 24 hours.

According to Van der Laan (166) in 1936, this species was somewhat sensitive to derris.

Corethra sp.

Danneel (66) in 1933 reported that Corethra larvae were uninjured after 24 hours in solutions of rotenone of 0.001-percent concentration (10 p.p.m.).

Culex hortensis Fic.

See Roman and Nétien (243) under Anopheles maculipennis on page 16.

Culex pipiens L., the northern house mosquito

See Roman and Nétien (243) under Anopheles maculipennis on page 16.

According to Gimlette (111) in 1923, H. E. Durham in England found in 1902 that larvae of Culex pipiens died in less than 16 hours (pupae in less than 24 hours) with solutions of 1:1,000, 1:2,000, and 1:5,000 of whole root of derris; with 1:10,000 the larvae were killed in 20 hours and the pupae in 24 hours. A solution of 1:1,000 of the extract is enough to make the water cloudy.

Gibson (107) in 1928 reported that in an experiment conducted at Hawkesbury, Ontario, Canada, when the powdered derris root was dusted on the surface of the polluted pools of water heavily infested, at the rate of 30 pounds per acre of water surface, 97 percent of the larvae were destroyed in 48 hours and 100 percent in 72.

Shepard (249) in 1931 tested the relative toxicity of rotenone and nicotine to mosquito larvae. In these experiments the rotenone was first dissolved in 95-percent alcohol. This alcoholic stock solution was made at a strength of 0.25 gm. in 100 cc. It was necessary to warm the mixture somewhat in a water bath in order to dissolve the rotenone entirely. On dilution with distilled water a stable milky suspension resulted. Both rotenone and nicotine were tested in duplicate at the same concentration on the same day. All the tests were made as quickly as possible. The spray mixtures were made fresh each day. Rotenone at 0.01 percent without spreader killed 34.5 percent of mosquito larvae immersed for 1/2 hour in the suspension, as compared with a kill of 10.5 percent obtained with nicotine under the same conditions.

Campbell, Sullivan, and Smith (55) in 1933 determined the relative toxicity of nicotine, anabasine, and other alkaloids, and of rotenone for culicine mosquito larvae, Culex pipiens L. and C. territans Walk. These tests against mosquito larvae showed that rotenone is much more toxic than nicotine. Although Shepard also found that rotenone is more toxic than nicotine for mosquito larvae, he did not do justice to rotenone, because he compared the two compounds at only one concentration, 0.1 gm. per liter (1:10,000). As shown by these authors, nicotine is not effective at concentrations slightly below 0.1 gm. per

at 0.1 gram per liter.
liter, whereas rotenone is as effective at 0.005 gm. per liter as it is/

Campbell, Sullivan, Smith, and Haller (56) in 1934 found that rotenone at 1:100,000 killed 46 out of 50 mosquito larvae (Culex pipiens, C. territans, and C. quinquefasciatus) in 20 hours, and at 1:200,000 it killed 47. The higher concentration killed half the larvae in 151 minutes, as compared with 272 minutes for the lower concentration.

The larvae of Culex pipiens L. and of Aedes vexans (Meig.) (=A. sylvestris (Theob.)) were used by Ginsburg, Schmitt, and Granett (112, 113) in 1934 to test the insecticidal value of various derris extracts. A fresh supply of larvae was collected daily during the testing period and brought into the laboratory. The very young larvae were either entirely removed or were not counted in the final results. Only larvae of substantial size, apparently from 3 to 5 days old, were used. This precaution was taken because it had been found previously that the very young larvae are more readily killed by toxic chemicals than are older ones. Furthermore, the young larvae are more sensitive to sudden changes of either media or atmosphere, as would inevitably be brought about by transferring from field to laboratory conditions. About 50 larvae were transferred to large porcelain dishes containing 500 cc. of mixed ditch water and tap water. The desired amount of extract in various dilutions was then added from a pipette and was stirred in with a glass rod. After 24 hours the dead and living larvae were counted. Several dishes were run for each test in order to obtain a minimum of about 200 larvae. Preliminary tests showed that acetone extracts of derris root are very toxic to mosquito larvae. Dilutions equivalent to 1 gm. of derris root in 10,000 parts of water or lower invariably produced a 100-percent kill of larvae and could not be used for comparative tests, therefore only dilutions ranging from 1:10,000 to 1:80,000 were run in this experiment. At dilutions of 10,000 20,000, and 40,000 the kill was equally high for all the extracts (except No. 7), ranging from 85 to 100 percent. At dilutions of 80,000 the water extracts proved considerably lower in toxicity than either the alcohol or the acetone extract. Pure rotenone proved much inferior to the extracts in toxicity to mosquito larvae. Dilutions of 1 part of rotenone to 1,000,000 and 2,000,000 parts of water gave 50 and 10 percent kills, respectively, while acetone extracts containing similar concentrations of rotenone gave 92 and 96 percent kills, respectively. The results of toxicity tests of various derris extracts to mosquito larvae were as follows:

Extract No.	Process of extraction	Dilution in gm. of root	Approximate dilutions in gm. of rotenone	Total larvae	Kill after 24 hours
				Number	Percent
1	Soxhlet acetone	1:10,000	1: 250,000	268	100
		20,000	500,000	290	96
		40,000	1,000,000	386	92
		80,000	2,000,000	205	80
2	Soaked in acetone	1:10,000	1: 250,000	---	--
		20,000	500,000	271	98
		40,000	1,000,000	286	85
		80,000	2,000,000	211	76
4	Soaked in alcohol	1:20,000		280	95
		40,000		286	90
		80,000		329	73
5	Cold water	1:10,000		208	99
		20,000		216	100
		40,000		433	94
		80,000		290	51
6	Hot water	1:10,000		226	100
		20,000		284	99
		40,000		346	86
		80,000		281	51
7	Mixture of acetone and water	1:10,000		208	93
		20,000		284	90
		40,000		368	74
		80,000		228	46
15	Pure rotenone dissolved in acetone		1: 250,000	292	92
			500,000	297	79
			800,000	213	70
			1,000,000	321	50
			2,000,000	265	10
Check (average from several series of tests)				880	3

The secondary extracts from the alcohol and acetone residues ranked very low in toxicity. On the other hand, the toxicity of the secondary extract from the water residue was practically as high at dilutions of 20,000 and 10,000 as were the primary extracts. The results of toxicity tests of secondary extracts of derris-root residue to mosquito larvae were as follows:

Extract No.	Extraction process	Dilution in gm. of root	Total larvae	Kill afer 24 hours
			Number	Percent
9	Residue from water reextracted with acetone	1:10,000	294	99
		20,000	220	90
		40,000	244	70
		80,000	251	27
10	Residue from acetone reextracted with water	1: 200	274	92
		400	292	90
		800	229	92
		1,600	242	48
12	Residue from alcohol reextracted with water	1: 400	232	94
		800	229	83
		1,600	221	51
Check			262	0

Culex quinquefasciatus Say, the southern house mosquito

See Campbell et al. (56) under Culex pipiens on page 17.

Badertscher and Wotherspoon (13) in 1935 compared the stability of treated derris and pyrethrum powders with that of untreated powders. Tests were made on several insects, including fourth instars of this species. Exposure to a light from a Uviarc mercury vapor lamp operating on 118 volts with a current of 4.8 amperes and 450 watts for 24 hours destroyed about half the toxicity of a derris powder containing 6 percent of rotenone and 18 percent of acetone extractives. Treated powders (treatment not described) prolonged the life of these powders when exposed to light. The authors concluded "(1) That derris powder requires at least twice as long as pyrethrum to lose most of its toxicity when exposed to the action of air and sunlight in the summer time. (2) That the rapidity of the loss of toxicity in pyrethrum powder and in derris powder is largely directly dependent on the intensity and duration of the light. (3) That derris powder loses its toxicity relatively much more slowly than does pyrethrum powder when exposed to air in the absence of direct light. (4) That treated derris powder after exposure to light and air shows an efficiency from 34 to 93 percent greater than untreated derris powder similarly exposed."

Fink and Haller (89) in 1936 reported on the relative toxicity to fourth instars of culicine mosquitoes (principally this species) of optically active and inactive rotenone derivatives. The optically active forms were more toxic than the corresponding optically inactive forms. The order of toxicity was active

dihydrodeguelin > rotenone > active isorotenone (= inactive dihydrorotenone) > deguelin > inactive isorotenone. Comparisons were made by plotting concentration (mg. per liter) against the reciprocal of the mean time (minutes) to kill 50 percent of the larvae. The authors believed that the toxicity of derris extractives can be attributed partly to the optically active deguelin known to be present.

Woke (324) in 1938 showed that the toxicity of finely powdered rotenone to mosquito larvae is not altered to a demonstrable extent after 18 hours of incubation in the dark at 29° C. with the contents of the digestive tract of the southern armyworm, various tissues or with the

Phillips and Swingle (234) in 1940 reported on the rearing of mosquito larvae of Culex quinquefasciatus Say at Sanford, Fla., and the effect of diet on their resistance to rotenone and nicotine. The percentage of kill after 18 hours by rotenone at 5 p. p. m. ranged from 15 to 91 percent, according to the diet. Of larvae collected in the field, 72 percent were killed by 5 p. p. m. of rotenone and 78 percent by 100 p. p. m. of nicotine.

Culex territans Walk.

See Campbell et al. (56) under Culex pipiens L. on page 17.

Culex sp.

Campbell (50) in 1932 published a critical review of the recently published literature on the insecticidal value of rotenone and of much unpublished data obtained by Federal and State entomologists. The action of rotenone on Culex sp. as determined by Davidson (67) in 1930 and by Shepard (249) in 1931 was reviewed.

Corbett, entomologist for the Federated Malay States Department of Agriculture (82) in 1934 reported that the effect of derris solutions on larvae of Culex sp. was tried, and comparative tests with nicotine sulfate were also carried out.

Miller (204) in 1935 described tests on various insects, including Culex larvae, for the evaluation of different species of Derris. Larvae of Culex sp. in 500 cc. of water were treated with 1 cc. of an aqueous solution of D. elliptica at a concentration of 1 kg. of root to 25 liters of water, and 94 percent of them were dead after 4 days.

Stegomyia sp.

Worsley (326) in 1934 reported that tests on mosquito larvae (10 in each test) of this species yielded the following results:

Material	Dilution	Larvae dead after-- 1 hour	24 hours
		Number	Number
Crude tephrosin	1:100,000	8	10
	1:250,000	1	4
	1:500,000	0	0
Alcoholic extract of	1:300	8	10
Tephrosia vogelii seeds	1:500	2	4
	1:750	0	1
Alcoholic extract of	1:100	9	10
Tephrosia vogelii	1:250	4	5
leaves	1:500	0	0
Water extract of	1:100	4	10
Tephrosia vogelii	1:250	0	5
leaves			

Theobaldia annulata (Schrank)

According to Gimlette (111), writing in 1923, H. E. Durham found in England in 1902 that larvae were killed in a 1:40,000 suspension of the dried powdered crude root of Derris elliptica. A solution of 1:10,000 killed the larvae in 29 hours and the pupae in from 24 hours to 3 or 4 days.

Culicidae (unidentified spp.)

Daniels (65) in 1905 wrote that a fragment of crushed fresh derris root can be used effectively under all circumstances under which kerosene can be used to destroy mosquito larvae.

Tattersfield and Roach (271) in 1923 reported work on derris done by Durham between 1902 and 1907. He found mosquito larvae and pupae to be usefully susceptible test insects.

De Ong and White (71) in 1924 reported that a commercial derris extract of 16-percent concentration diluted 1:500, added to mosquito-infested water, killed 65 percent of the larvae but had no effect on the pupae. The powdered derris root (undiluted) sprinkled on the surface of the water killed 90 percent of the larvae in 2 to 4 hours.

Castillo (59) in 1926 reported the results of studies on the insecticidal properties of three species of Derris growing in the Philippines, namely, D. polyantha Perk., D. philippinensis Merr., and D. elliptica Benth. The roots were cut into thin transverse slices and dried in an oven at 40° C. until the weight remained fairly constant. The dried material was then comminuted in a mortar and the powdering finally completed in a meat grinder. The fine powder was separated from the fibers by sifting through fine-meshed cloth. On mosquito larvae the most effective concentrations

of Derris philippinensis in bringing about the highest percentage of deaths in the shortest time was 3:1,000. Solutions either more dilute or more concentrated than 3:1,000 were less effective. Concentrations of 1:1,000 killed 19 percent of the larvae in 5 days; lower concentrations showed no effect at all. A concentration of 3:1,000 or higher retained its toxicity against mosquito larvae 13 to 16 days. Against both mosquito larvae and aphids, Derris polyantha was more effective than either of the other two species. In aqueous solutions it showed its superiority against both insects (1) in bringing about the highest percentage of deaths, (2) in the short time it required to kill, and (3) in the retention of its virulence. Derris polyantha retained its virulence in water and was toxic to mosquito larvae for 13 to 16 days. Derris elliptica and D. philippinensis were toxic for only 1 to 2 days.

Durham (78) in 1926 gave an interesting account of his early work with derris, which he regarded as essentially a stomach poison. Field trials started in the Malay States in 1902 showed it to be a potent agent for the destruction of mosquito larvae.

Kelsall et al. (159) in 1926 reported that derris, at approximately 1 pound per 100 imperial gallons, added to a large tank of water very heavily infested with mosquito larvae, killed all the larvae in 3 or 4 days.

The Canada Experimental Farms, Division of Chemistry (57) in 1927 stated that derris had been found very effective as an agent in mosquito-control work.

In 1929 the Imperial Institute (146) reported the results of tests made by the Entomological Branch of the Department of Agriculture in Nigeria, Africa, with Tephrosia vogelii. An aqueous extract of the leaves was tested on mosquito larvae, but the larvae thrived even in strong solutions. Adult mosquitoes seemed to be attracted to the extract for oviposition.

Davidson (67) in 1930 reported that when pure rotenone dissolved in acetone was added to a tub of water to give a rotenone concentration of 1:1,150,000, from 98 to 99 percent of the culicine larvae were killed within 5 days, the eggs present hatched, and the resultant larvae died within 2 days. Rotenone at 1:2,300,000 killed 95 percent of the larvae in 6 days, but the remainder transformed into pupae, the eggs present hatched, and 20 percent of the resultant larvae survived. Larvae and eggs in untreated tubs showed no abnormal mortality.

Fulmer (90) in 1930 wrote that derris destroyed mosquito larvae when applied at the rate of 1 pound to each 1,000 imperial gallons of the water in which the larvae are present.

Danneel (66) in 1933 reported that 7 hours was necessary to cause loss of motion in mosquito larvae in solutions of rotenone of 0.001 percent concentration (10 p. p. m.).

Gnadinger (117) in 1933 cited unpublished work by Ginsburg which indicates that the pyrethrins are more toxic than rotenone to mosquitoes.

Jones et al. (156) in 1933 reported on the loss in toxicity to insects of deposits of rotenone and related materials when exposed to light. Rotenone, dihydrorotenone, rotenone hydrochloride, rotenone-bentonite (1:1), rotenone-lampblack (1:1), ground derris root, and powdered derris extract were each made into a paste with water and painted heavily on weighed glass slides. After the deposits had dried the slides were weighed again. One group of slides was exposed to direct sunlight for 10 days during April and May, a second group to sunlight for 20 days, a third group to arc light for 240 hours, a fourth group, of the three pure compounds only, to arc light for 480 hours, and a fifth group was kept in the dark at room temperatures. The deposits on these slides were tested against culicine mosquito larvae and goldfish to determine the percentage loss of toxicity resulting from exposure to light. In all cases the exposed deposits were decidedly less toxic than the unexposed and, with one exception, the loss of toxicity increased with increasing exposure. Rotenone, rotenone-bentonite, derris root, derris extract, and rotenone hydrochloride lost more than half of their toxicity during 10 days' exposure to sunlight. Their toxicity was practically destroyed by the exposure to arc light. Since dihydrorotenone lost only one-fourth to one-third of its toxicity during the first 10 days' exposure to sunlight it was distinctly more resistant to detoxication during this period than rotenone. At the end of 20 days in sunlight, however, and after exposure to arc light, it had lost toxicity to about the same extent as rotenone. Lampblack markedly reduced the loss of toxicity of rotenone during the first 10 days' exposure to sunlight and prevented further loss during the last 10 days. It also gave some protection to rotenone under arc light. Neither bentonite nor the substances occurring with rotenone in powdered derris root and derris extract protected rotenone from loss of toxicity. The unexposed powdered derris extract containing about 25 percent of rotenone was as toxic to mosquito larvae as pure rotenone. It was shown that the photochemical decomposition of dry rotenone, which results in loss of its toxicity to insects and fish, does not take place in the absence of oxygen.

Spoon (257) in 1933 reported tests of rotenone as an insecticide in Holland and stated that rotenone appeared to have no value against full-grown mosquitoes.

Turner (278) in 1933 recorded tests of insecticides against mosquito larvae in Connecticut. Preliminary tests made in 1931 showed that the use of rotenone with fuel oil was not so effective

as pyrethrum. Rotenone in suspension was also lower in toxicity than anticipated. Moreover, rotenone is known to be highly toxic to fish and, therefore, was dropped from consideration.

Worsley (326) in 1934 reported that an alcoholic extract of tephrosin is as effective against mosquitoes and similar insects as pyrethrum if the insects are actually hit with it.

Tischler (275) in 1935 studied the mechanism of how derris kills insects. Studies on the heart rates of various insects including mosquito larvae showed that the rate of pulsation was markedly decreased before the insects exhibited incoordinated movements. Derris inhibits oxygen utilization by the tissues and its detrimental effects are general rather than specific to any organ.

Feytaud and Lapparent (87) in 1936 published the following formula for a mosquito spray: Cube powder or derris powder 10 gm. and pyrethrum powder 10 gm., is macerated in 100 gm. of a mixture of equal parts of terpinolene and orthodichlorobenzene or carbon tetrachloride for 5 days with frequent agitation, then the product is filtered and a perfume is added, for example, 10 percent of "terpene de citronelle."

Phillips (233) in 1938 reported a study of the effect of 13 diets on the resistance of mosquito larvae to nicotine, rotenone, and phenothiazine. By feeding various diets to different groups of larvae it was possible to cause a variation of 75 percent resulting from nicotine and rotenone in the mortality of fourth instars. The variation in the results from phenothiazine was not so great, because in most cases the concentration used was high enough to cause complete mortality. In general, the better diets caused more rapid growth and resulted in more resistant larvae. The diets did not have the same effect, however, with all three insecticides--in other words, the larvae most resistant to rotenone were not the most resistant to nicotine or phenothiazine.

Sullivan, Phillips, and McGovran (268) in 1938 reported that an extract of the fruit of the Amur cork-tree (Phellodendron amurense) was more toxic to mosquito larvae than was a derris standard containing 5.2 percent of rotenone.

Thomssen and Doner (274) in 1938 reviewed published information on fly control for livestock and mentioned rotenone for the control of mosquito larvae.

The Division of Control Investigations of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture (292), in February 1938 reported tests with derris as follows:

Concentration p. p. m.	Mortality of fourth instars after 18 hours	
	Not exposed	Exposed
	Percent	Percent
20	40	11
50	94	53

The same Division (293), in May 1938, reported results of tests with derris and cube on fourth instars as follows:

Material	Dosage per sq. cm.	Mortality in 18 hours
	Micrograms	Percent
Derris (rotenone 5.4 percent; total extractives 15.5 percent	20	98
	100	100
	20	100
	100	100
Derris-talc (rotenone 1 percent)	20	27
	100	91
	20	28
	100	100
Derris-talc (rotenone 0.5 percent)	20	0
	100	67
	20	39
	100	100
Cube (rotenone 4.4 percent; total extractives 20.7 percent)	20	95
	100	98
	20	100
	100	100

H. A. Jones (153) in 1939 reported the presence of alkaloids in cube root (0.08 and 0.40 percent in two specimens), timbo root (0.15 percent), and derris root (0.02 percent). The alkaloidal material was nontoxic to mosquito larvae at a concentration of 1:10,000.

An anonymous writer (8) in 1941 reported that the name "Indalone" had been registered as the trade mark of the solvent alpha, alpha-dimethyl-alpha'-carbobutoxy-gamma-dihydropyrone, which was developed for use in liquid contact insecticides as a solvent for derris-root extractives. When used in this way, it has the property of increasing the insecticidal effectiveness of the ingredients dissolved in it and of holding derris extractives in solution in the commonly used base oils. Indalone is a powerful insectifuge and repels the common winged insects, to which it appears to have an obnoxious taste. Because of this high repellency, it is especially suitable for cattle sprays and mosquito lotions.

Drosophilidae

Drosophila ampelophila (Loew.), a pomace fly

Patterson (227) in 1935 published the indices of toxicity of a

number of poisons when fed to adult fruitflies. Three feeding media or baits were used, (1) apple sirup, (2) molasses, and (3) cane sugar-glycerine. The apple sirup and molasses were of ordinary commercial grade. They were diluted with tap water before the poisons were added; the apple sirup and molasses to concentrations of 12.5 percent, and the cane and sugar-glycerine to 5-percent cane sugar and 2.5 percent glycerine. Poisons were all compared at 6 concentrations, 1:200, 1:400, 1:800, 1:1,600, 1:3,200, and 1:6,400. A wad of cotton wool was thoroughly soaked in each of the poisoned baits and the excess liquid squeezed out. Finally each wad was placed in the bottom of a shell vial of about 20 cc. capacity and 10 flies were introduced. After being loosely stoppered with cotton wool the vials were set away. Vials with unpoisoned baits were included as controls. All tests were in duplicate, so 20 flies were used at each concentration for each feeding medium. Dead flies were recorded daily for a week when the test was concluded. Derrisine gave an index of toxicity of 20.4 in apple sirup, 29.3 in molasses, and 59.2 in the cane sugar-glycerine mixture. The corresponding values for Derrisol were 0.4, 0.7, and 2.0. Rotenone in cane sugar-glycerine gave an index of toxicity of 7.7. The most toxic material was 3.5-dinitro-orthocresol, which gave indices of toxicity of 99.1, 95.8, and 91.6, respectively, in the 3 baits. Powdered derris gave a toxicity index of 6.4 in the cane sugar-glycerine mixture, whereas derris extract in glycerine (1:5) was without toxicity.

Drosophila sp.

The adults were used by the Federated Malay States Department of Agriculture (83) in 1936 to test the toxic value of derris extracts.

Craufurd-Benson (64) in 1938 reported that larvae are not susceptible to a derris preparation when dipped in it.

Hippoboscidae

Pseudolynchia canariensis (Macq.), the pigeon fly

Bishopp (27) in 1929 reported that derris powder was nearly as effective as pyrethrum powder. From one to three pinches of the powder, depending on the size of the bird, when scattered among the feathers destroyed all flies present. Two proprietary extracts of derris root used at the rate of 1/2 ounce and 2 ounces to the gallon also gave a complete kill. The slight staining of the feathers from the pyrethrum extract, especially on white birds, might be somewhat objectionable. The derris products do not stain.

Melophagus ovinus (L.), the sheep tick

Wille et al. (322) in 1937 reported on the use of cube in dips against M. ovinus in Peru. In 1935 more than 300,000 sheep were treated

with cube dip in the Junin area, and 150,000 in that of Puno. The dips were obtained either from an extract prepared by soaking the chopped roots in water 48 hours, or from a powder ground so fine that 85 percent passed a 0.074 mm.-mesh sieve. In 1936 J. F. Mitchell stated that the powder yielded a dip that was more saponaceous, and therefore penetrated better, than that from the extract. Dips made with the powder did not keep more than 48 hours, whereas those made with the extract kept a week. The addition of 1/2 pound of soap per 100 gallons was recommended, and also that of 1/2 pound of sodium carbonate to counteract the hardness of the water. For complete control of the parasites, sheep usually required 2 dips, with about a fortnight interval, twice a year, except in serious infestations, when a third pair of dips was necessary. The effective concentrations of ground cube root containing 6.8 percent of rotenone, and of extract containing 5.5 percent of rotenone were, respectively, 1:2,000 and 1:10,000. The ground root and the extract were equally effective and were in no way inferior to other dips.

Edwards (79) in 1938, in a popular account of rotenone-containing insecticides, stated that they are effective against the sheep ked.

Stewart (264) in 1939 reported tests of 5 dips for the control of ticks on sheep in Scotland; (A) A plain derris dip (solution of derris extract), (B) derris-carbolic paste, (C) derris-carbolic-wool fat paste, (D) arsenic-carbolic paste, and (E) a commercial tick-dip (Highland Tick Paste containing both arsenic and derris). Those derris dips that did not contain arsenic possessed negligible tick-deterrent properties. It was found that such dips are efficient tick-killing agents, but under the conditions of the above test they showed little value as repellents. This finding is not in agreement with the results of critical small-scale tests, and MacLeod suggests (in a personal communication to R. C. Roark) that the discrepancy lies in the difference in immersion time. The average hill shepherd immerses his sheep for something less than 15 seconds. The duration of the actual immersion period appears to be more important with derris than with other dips. The most satisfactory dip reported by Stewart proved to be dip E, which showed a marked deterrent effect 2 weeks after use. Dusting newly born lambs with a derris preparation gave better results than dipping in a diluted derris extract, or treating with an oily smear containing derris.

The New Zealand Department of Scientific and Industrial Research (218) in 1940 reported that sheep-dip investigations on sheep infested with keds and lice, and treated in dips of various compositions, indicated that all the preparations containing arsenites, phenols, and rotenone were effective against adult keds, but in order to be thoroughly effective the toxic influence should be protracted long enough to deal also with the keds that emerge from the pupae. Incomplete trials indicated that derris possesses value for giving this delayed action.

Itonididae (= Cecidomyidae)

"Cecidomia negri"

According to the Etablissements Rotenia in 1938, in a letter to R. C. Roark, "Cecidomia negri" [Lestremia nigra Blanchard may be intended] on pear trees was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum.

Contarinia nasturtii Kieffer

Leefmans (172) in 1938 reported that deformed heart of cabbage and cauliflower due to infestation by this species has caused considerable loss in northern Holland since it was first observed in 1897. The adults were found to be sensitive to derris and pyrethrum dusts. Headed cabbage must be sprayed twice a week, but in slight infestation of cauliflower one application weekly may suffice. Derris may be recommended as a dust insecticide, but spraying with a strong jet is more effective, as it tends to wash away both larvae and eggs.

Contarinia pyrivora (Riley), the pear midge

The University of Bristol Agricultural and Horticultural Research Station (39) in 1936 reported that field trials to test the efficacy of a preblossom derris spray for control were defeated by the severe late frosts at two centers. At the third the results were not satisfactory.

DeBussy et al. (48) in 1936 reported that the maggots are not affected by derris and results against the adults were unsatisfactory.

Contarinia tritici (Kby.)

Yuasa (328) in 1936 reported that sprays containing either nicotine sulfate or derris were effective for control of the wheat midge.

Mühlow and Sjöberg (208) in 1937 reported on control of the wheat gall midges. No reduction in infestation was observed when plots were dusted heavily with pyrethrum powder or derris or sprayed with a solution of rotenone.

Dasynura mali Kieffer

The Massachusetts Agricultural Experiment Station (199) in 1937 reported that for control of the leaf-curling midge on apple derris extract, summer-oil emulsion, and lime-sulfur were about equally efficient in reducing the number of curled leaves and were more effective than nicotine sulfate and a combination of soluble and insoluble nicotine. Three and four applications were generally more effective than one or two treatments, and this is significant because

the trees receiving three and four sprays were nearer the most heavily infested unsprayed trees. Spraying caused a reduction of 55 to 85 (200) percent in the number of infested tips. In 1938 this station reported that wettable cube powder containing 3.65 percent of rotenone, used at the rate of 6 pounds in 100 gallons, with the addition of 3 pounds of water-soluble diglycol stearate wax as a spreader and sticker, applied to McIntosh and Richard 3-year-old trees was the most effective treatment. In experiments against the second generation nicotine sulfate 1:800 plus molasses 3 percent was the most effective treatment and reduced the infestation 48 percent on Golden Delicious. The cube-wax mixture was good and averaged the best for both series. It was concluded that spraying alone is not a practical means of combating this species.

Diarthronomyia hypogaea (Loew.), the chrysanthemum gall midge

Penick and Co. (230) in 1933 reported that Foliafume (which contains both pyrethrum and derris extracts), diluted 1:400 with water, gave an average mortality of 89 percent after 48 hours.

Monarthropalpus buxi Lab., the boxwood leafminer

Hamilton (131) in 1925 reported tests made in 1922 with Derrisine, a commercial preparation of derris. Derrisine diluted 1:500 was applied in a mixture of blackstrap molasses, 1 part to 4 parts of water. Both nicotine sulfate and free nicotine gave better control than the Derrisine.

Turner (277) in 1932 reported that rotenone had not been effective in preventing injury.

Mycodiplosis alternata Felt

Felt and Bromley (86) in 1939 reported on the life history and control of the dogwood club-gall midge. In 1938 a spray of 4 pounds of rosin-residue emulsion and 4 pounds of cube powder to 100 gallons of water was used, the applications being made May 14, 18, and 28, and June 14, and a badly infested tree in the tree garden showed no new galls on July 7, and only eight on October 10, indicating material reduction with this treatment.

Thecodiplosis mosellana (Gehin), the wheat midge

Yuasa (328) in 1936 reported that sprays containing nicotine sulfate or derris were effective for the control of adults of (Sitodiplosis) Thecodiplosis mosellana (Gehin).

Mühlow and Sjöberg (208) in 1937 reported on the control of the wheat gall midges. No reduction in infestation was observed when plots were dusted heavily with pyrethrum powder or derris, or sprayed with a solution of rotenone against (Clinodiplosis) Thecodiplosis mosellana (Gehin).

Muscidae

Siphona irritans (L.), the hornfly

The Louisiana Agricultural Experiment Station (183) in 1925 reported that Derrising in a fish-oil-soap emulsion of red-pine oil was effective in controlling or repelling hornflies on cattle.

E. W. Laake, of the Dallas, Tex., laboratory of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in a typewritten report to the Division of Insects Affecting Man and Animals in 1936, reported that powdered cube root, rotenone concentrate, and many other materials were ineffective as repellents.

Bruce (43,44) in 1940 reported results of tests on the medication of cattle for the control of larvae in the droppings. The general idea was to feed the cattle certain chemicals, which would pass out in the droppings and render them toxic to the larvae. The most effective material tested was rotenone. Doeses of 0.4 gm. per hundredweight killed all larvae in the droppings for approximately 30 hours.

Musca domestica L., the housefly

See Doty (76) under Stomoxys calcitrans (L.) on page 49.

McIndoo, Sievers, and Abbott (193) in 1919 reported the results of tests of derris powder. In cage tests, where flies were dusted in ordinary flytraps about 10 inches high, all were dead or inactive within 24 hours. In room tests, where the powder was freely blown into the air and all parts of the room with a small hand dust gun, all the flies were dead at the end of 16 hours. In one test several hundred flies were liberated in a room that had been thoroughly dusted 7 days before. Very few active flies were to be seen 24 hours later and on the second day only 3 or 4 were living.

Kelsall et al. (159) in 1926 reported the results of tests in which derris at the rate of 5 pounds per 100 imperial gallons of water was sprayed on the flies. The spray was shot at them both while they were resting and while they were on the wing. Such flies became restless almost immediately and began cleaning themselves vigorously. Most flies were dead within 24 hours and all appeared to be dead within 48 hours. Derris was also dusted on flies but its action was much slower and after 1 day none were dead, so it was not considered effective. Had these flies been kept under observation longer, a subsequent mortality might have been noted. Derris spray was also observed to kill several other flies of undetermined species.

Fulmer (90) in 1930 reported that houseflies were amenable to derris.

Laake et al. (165) in 1931 reported the results of tests of materials as attractants or repellents. Beef-liver bait, 4 ounces, to which 5 gm. of derris powder was added, attracted only 10.8 percent as many flies as did untreated bait. A mixture of 1 part of derris powder and 9 parts of kaolin attracted 6.3 percent.

Little (182) in 1931 compared the insecticidal properties of Tephrosia virginiana and derris. The powdered root of the devil's-shoestrings suspended in water at 1:800 and sprayed upon flies, with no spreader, killed from 3.6 to 74.3 percent (according to the origin and treatment of the root). Derris in similar tests at 1:800 killed 78.2 to 85.3 percent of the flies.

Campbell (50) in 1932 reviewed unpublished work by Davidson, who made 15 tests of rotenone as a stomach poison against flies. Eight tests were made in screen cages in a greenhouse and 7 in a room of 500 cubic feet. Rotenone was dissolved in acetone and added to diluted condensed milk or to a dilute solution of molasses. Cotton was soaked in the mixtures and exposed in petri dishes to the flies. The food was not renewed during a test. Each test was paired with a check, in which flies were given unpoisoned food. The flies used in most of the tests were between 1 day and 2 days old. The numbers of flies used per test ranged between 18 and 118. In 6 tests all flies were killed in 28 to 72 hours. In 5 other tests more than 90 percent were killed in 24 to 48 hours. The quantities of rotenone in the cotton ranged from 10 to 100 mg. In one test only 0.8 mg. of rotenone was used, but a mortality of 84 percent was obtained in 94 hours. Except in one case, little or no mortality occurred in the checks. It was concluded that rotenone will kill flies by way of the alimentary tract but that its toxic action is slow. In a few additional experiments with rotenone as a stomach poison, Davidson gave the flies a choice of poisoned and unpoisoned milk. As would be expected, the mortality was lower than in earlier experiments, when the flies had access to poisoned food only. A satisfactory kill did not result after exposure for 2 days. As comparisons were not made at the same time between poisoned foods only and poisoned food with unpoisoned food, it is not certain that rotenone had a deterrent effect on the flies, although such an effect is probable.

Campbell (50) in 1932 reviewed all work done up to that time with rotenone against the housefly. Campbell and Sullivan found that this fly was among the species most resistant to aqueous suspensions of rotenone. Suspensions of 1:5,000 apparently had no affect on houseflies, although when the flies were examined under the microscope after the treatment, crystals of rotenone could be seen distributed over the integument. Against the housefly, rotenone need not be applied in suspension in water, but may be applied in solution in an organic solvent. Kerosene, so largely used as a solvent and carrier for the pyrethrins in household sprays, is not a good solvent for rotenone; however, the effectiveness of a saturated solution in kerosene has not yet been determined. It seemed more promising to mix kerosene with a solution of rotenone in an organic liquid that is miscible with

kerosene, the mixed solvents carrying a higher percentage of rotenone in solution than would kerosene alone. Davidson tested a 1:2,000 solution of rotenone in kerosene-ethylene dichloride in a standard fly chamber (6 ft. by 6 ft. by 6 ft.) at temperatures ranging from 69° to 88° F. Five tests were run and each test was paired with a check of the mixed solvent without rotenone. From 11 to 33 cc. of the liquid was sprayed into the chamber, half of it through a hole in one side and half through a hole in the opposite side. The mixed solvents alone had little or no effect on the flies, but the rotenone solutions paralyzed from 29 to 84 percent of them in 10 minutes, depending on the volume of the solution sprayed into the chamber. Commercial pyrethrum fly sprays, when tested in the same way, paralyzed a larger percentage, but rotenone sprays may kill a greater percentage of those affected. In Davidson's test with 33 cc. of the rotenone solution, 43 out of 51 flies were brought down and 42 of these died.

Campbell and Sullivan compared the effects on houseflies of 1:10,000 solutions of the pyrethrins and of rotenone in absolute alcohol. A very marked difference in the initial and final effects of the sprays was observed. At first all the flies were paralyzed by the pyrethrins, whereas none were visibly affected by rotenone. Then, as the flies treated with thepyrethrins began to recover, those treated with rotenone began to be affected. After 24 hours practically all the flies treated with thepyrethrins had recovered, whereas a considerable number were dead or dying from the effects of rotenone. The final 48-hour count showed 2-percent mortality for the pyrethrins and 22-percent mortality for rotenone. It might be advantageous to apply the pyrethrins and rotenone together in order to utilize simultaneously the rapid paralyzing action of the one and the slow killing power of the other. From a toxicological point of view it would be desirable to test the pyrethrins and rotenone together and separately in order to determine to what extent their combined effect is additive.

Houseflies were being used by Campbell and Sullivan as test insects for the determination of the relative toxicity of rotenone and related compounds. The spraying chamber consisted of a glass cylinder 8-1/2 inches in diameter and 17 inches high, and a bell jar of the same diameter and 13 inches high, which rested on top of the cylinder. The cylinder stood on a shallow copper tray in which the flies were confined. The top of the tray could be opened or closed at will by a sliding copper plate. A spray gun was mounted in the hole at the top of the bell jar and connected with a compressed-air line. The flies in the tray at the bottom of the cylinder could be sprayed directly, or by manipulation of the copper plate could be exposed for any desired period to a settling fog of the spray. Treatments could be made in the cold or at room temperature. When the treatments were made in a cold room at 32° F., 50 immobile flies were placed on their backs on a circle of filter paper on the bottom of the tray. After the treatment the flies were transferred to cages placed immediately in a high-temperature room at 83° to

84° F. Here they regained their mobility in about 5 minutes and the poison took effect. Counts of dead and dying flies were made at the end of 46 to 48 hours. Under these conditions an acetone solution of rotenone (1:5,000) killed about 40 percent of the flies. When active caged flies were treated in the same way at room temperature, the 1:5,000 solution killed about 90 percent.

Tests in the cold room led to one significant result that could not have been obtained at higher temperature. With immobile flies it was shown that the effect of the 1:5,000 treatment depends on the position and exposure of the insect's body with respect to the settling fog. When the flies were placed on their feet so that the fog settled on the wings and dorsum, they were not affected. When they were placed on their backs so that the fog fell on the venter and pleural area many were killed. When they were placed on their backs and the heads or abdomens were covered the mortality was greatly reduced, indicating that the poison probably enters all three regions of the body when the flies on their backs are fully exposed. Although the treatments in the cold were of the greatest possible uniformity, the results from day to day varied as much as those obtained at higher temperatures. Later tests were therefore made at 83° to 84° F. with the apparatus described above. For each test 50 chilled flies 2 days old were counted out into a large petri dish, which was then covered with wire screen. When the flies had resumed their normal activity, the dish was placed in the bottom of the copper tray and the spraying chamber was assembled above it. Absolute ethyl alcohol was used as the solvent for rotenone and related compounds because it has no permanent effect on the flies. Alcohol was preferred to acetone for work at high temperatures because it does not evaporate so rapidly. At 20 pounds' pressure about 10 cc. of the alcohol solution was sprayed into the chamber with the flies exposed. The spraying operation took about 10 seconds, after which the flies were exposed to the settling fog for 3 minutes, and were then transferred to a cage with food. Final counts of dead and moribund flies were made at the end of 46 to 48 hours. Results are expressed as percentage of effect, each dead fly equalling 2 percent and each moribund fly 1 percent. The rearing, spraying, and observation of treated flies were all done in the same constant-temperature room. The following average results were obtained in terms of percentage of effect of 1:5,000 solutions: Rotenone 86.4 percent (10 tests), dihydrorotenone 65.5 percent (10 tests), rotenone hydrochloride 30 percent (10 tests), acetyl rotenone 25 percent (7 tests). The following compounds produced less than a 10-percent effect, hence cannot be classified in order of value until tested at higher concentrations: Isorotenone, desoxyrotenone, dehydrorotenone, rotenonic acid, dihydrorotenonic acid, acetyl rotenolone, and acetyl dihydrorotenolone.

Gnadinger and Corl (118) in 1932 reported on the relative toxicity of pyrethrins and rotenone as fly-spray ingredients. Mixed pyrethrins (66.8 percent pyrethrin I and 33.2 percent pyrethrin II) in a highly refined Pennsylvania mineral oil, "Deocene" (63.4 mg. per 100 cc.), caused an average knock-down of 94 percent and an average kill of 46

percent when tested on houseflies by the Peet-Grady method. Rotenone at the same concentration gave an average knock-down of 76 percent and an average kill of 30 percent. A mixture of 31.7 mg. of pyrethrins with 31.7 mg. of rotenone gave an average knock-down of 85 percent and an average kill of 42 percent. Because of the low solubility of rotenone in the oil, 5 percent of acetone was added to the solution. Allowance was also made for the petroleum ether introduced when the stock solution of pyrethrins was diluted with the mineral oil. All the solutions tested, therefore, contained 5 percent of acetone and 7.2 percent of petroleum ether, by volume. Neither acetone nor petroleum ether was toxic to flies in these concentrations. The mineral oil gave a kill of less than 6 percent by the Peet-Grady method. The authors concluded that the addition of small amounts of rotenone to oil solutions of pyrethrins does not increase the toxicity as much as does the addition of the same amount of pyrethrins.

The United States Department of Agriculture, Bureau of Entomology (287), in 1932 reported that tests of alcoholic solutions of rotenone and 13 derivatives of it against houseflies showed that rotenone was more toxic than these derivatives, that dihydrorotenone was nearly as toxic as rotenone, followed by rotenone hydrochloride and acetyl rotenone, and that the other 10 derivatives were relatively nontoxic. Tests against the housefly of dusts of derris root and of rotenone showed that this species is killed by extremely small quantities of both. Comparative tests of powdered derris root and of the same root from which rotenone had been extracted showed that thoroughly extracted root was not toxic to houseflies. Comparative tests of alcoholic solutions of the pyrethrins and rotenone showed that the former has a more rapid effect on houseflies, but that the insecticidal value of the latter is greater. Rotenone when sprayed in alcoholic solution on houseflies acted as a contact poison. It had no effect on flies when administered in suspension by mouth, nor did it have any effect in the vapor phase at room temperature.

Badertscher (10) in 1933 reported the results of fly tests with solutions containing both pyrethrum extract and rotenone. Samples representing four brands of commercial fly sprays were diluted with an equal volume of a base solvent (Deobase) containing 0.1 percent of rotenone. These mixtures were compared by the Peet-Grady method with the original samples and also with the original samples diluted with an equal volume of base solvent. In all cases the addition of rotenone increased the killing power of the sprays to flies. Badertscher concluded that 0.05 percent of rotenone in a housefly spray has value, but that the intelligent use of rotenone in this field requires a knowledge of the amount of active principles of pyrethrum with which it is to be incorporated.

Campbell and Sullivan (51, 52) in 1933 reported the results of 13 series of tests, showing that a kerosene extract of a good

sample of derris was more effective as a housefly spray than a similar keorsene extract of a good sample of pyrethrum. Pyrethrum was speedier in its initial action. Theoretically, mixtures of derris and pyrethrum extracts should combine the advantages of both. The same authors reported later in the year that only 1 of 9 samples of Tephrosia native to the United States (T. latidens from Florida) had shown any promise when tested as a kerosene extract against houseflies. It was not so effective as a sample of derris.

Campbell, Sullivan, and Smith (55) in 1933 determined the relative toxicity of nicotine, anabasine, and other alkaloids, and of rotenone for control of houseflies. Rotenone, 0.1 gm. per liter of absolute ethyl alcohol, sprayed on flies in a screen-covered petri dish at the bottom of a cylindrical glass spraying chamber, usually killed more than 50 percent of the flies. None of the alkaloids affected them.

Gstirner and Hünerbein (127) in 1933 tested samples of barbasco root and bark, thought to be Tephrosia piscatoria, against houseflies. With the ether extract of the root, a significant insecticidal effect was obtained, but this was very much less than the effect of pyrethrum flowers. The bark had no toxic effect against houseflies.

H. H. Richardson (239) in 1933 tested kerosene extracts of derris, both alone and mixed with kerosene extracts of pyrethrum, against flies. Kerosene extracts of derris powder (2.9 percent rotenone) were prepared by first macerating the powder for several hours with kerosene in a glass percolator and then allowing percolation to proceed slowly. Extracts were prepared on the basis of 23.8 gm. of powder to 100 cc. of kerosene (approximately 2 lb. to 1 gal.). Pyrethrum extracts were prepared by the same method in the proportion of 11.9 gm. of pyrethrum powder (0.26 percent pyrethrin I) to 100 cc. of kerosene (approximately 1 lb. to 1 gal.). The combination of derris extract with pyrethrin extract was prepared by adding 16.6 cc. of the derris extract, prepared as above, to 83.3 cc. of the pyrethrum extract. This was tested in comparison with another sample of the same pyrethrum extract, diluted with 16.6 cc. of kerosene to 83.3 cc. of the extract. The results of the insecticidal tests were as follows:

Test solution	Tests	Flies	Average time required to paralyze	Mortality after 24 hours
	Number	Number	Seconds	Percent
Kerosene	2	94	405	18
Kerosene extract of derris	2	110	332	68
Extract of pyrethrum	4	197	197	46
Extract of pyrethrum plus derris extract	4	198	190	59

Kerosene extracts of derris were much more toxic than kerosene alone. The addition of small quantities of derris extract to pyrethrum extract apparently gave a significant increase in toxicity. Whether the toxicity of the kerosene extract of derris was due to rotenone is a question. Certainly rotenone was present. Jones and Smith (157) report that the solubility of rotenone in kerosene at 20° C. is less than one-tenth of 1 percent. Possibly extractives of derris other than rotenone contributed to the toxicity of the kerosene extract. Derris apparently contains some kerosene-soluble compounds, which add considerably to the toxicity of the kerosene toward houseflies.

Bock (35) in 1934 reported that an aqueous extract of derris, made into a sirup with sugar, proved lethal to flies that fed on it. The active constituents of this extract were soluble in ether. The marc from the aqueous extract gave even more effective extracts with alcohol and ether. Large dosages caused regurgitation.

Campbell, Sullivan, and Jones (53,54) in 1934 reported the results of a comprehensive study of kerosene extracts of derris root as housefly sprays. Kerosene extracts of four samples of derris root, three of cube root, and one of haiari stems were tested against houseflies by a modified laboratory method. All were effective. The extracts of derris were on the whole more effective than those of cube. The extract of haiari stems was the least effective. Rotenone is not the only toxic component of kerosene extracts of these plant materials, but it appears to be an important one. Methoxyl content may be a better chemical index of the insecticidal value of rotenone-bearing plants than rotenone content. Deguelin, tephrosin, and toxicarol were tested in alcoholic solution in comparison with rotenone. Deguelin was nearly as effective as rotenone, tephrosin slightly effective, and toxicarol ineffective. These investigators also made comparative tests of extracts of derris and of pyrethrum against houseflies. Comparable kerosene extracts of good samples of derris root and of pyrethrum flowers were tested against houseflies in a small glass chamber, in Peet-Grady chambers, and in rooms. The pyrethrum extracts were more effective in paralyzing flies, the derris extracts were more effective in killing them. It was believed that kerosene extracts of derris have practical possibilities as housefly sprays.

Dibble (73) in 1934 recommended a cattle spray made by soaking 1/2 pound of ground pyrethrum flowers in 1 gallon of mineral spirits for 48 hours. Water solutions containing pyrethrum and derris were tried but with indifferent success. They worked more slowly and probably killed fewer flies.

The United States Department of Agriculture, Bureau of Entomology (289), in 1934 reported that kerosene extracts of roots of derris, cube, and Tephrosia virginiana, and of haiari stems, tested against houseflies, led to the following conclusions: Rotenone is not the only toxic component of kerosene extracts of rotenone-bearing plants, but it appears to be an important one. A given weight of derris root

is likely to yield a larger volume of effective kerosene extract than the same weight of pyrethrum flowers. Pyrethrum extracts are more effective in paralyzing flies, derris extracts more effective in killing them. Kerosene extracts of the samples of Tephrosia at hand were not so promising as were those of derris and cube. Both kerosene extracts and acetone extracts of rotenone-bearing plants were tested to find out the relations between chemical composition of the roots and effectiveness of the extracts against houseflies. Rotenone content was usually a good index of insecticidal value, but in some samples of derris their extracts were more effective than their rotenone content indicated. The value of these aberrant samples was indicated by the percentage of total acetone extractives or methoxyl content. In the samples of derris and cube studied, effectiveness was correlated on the whole better with methoxyl content than with any other single chemical determination.

Jones, Campbell, and Sullivan (155) in 1935 reported tests on 32 samples of both kerosene and acetone extracts of Tephrosia, collected in different parts of the United States, against houseflies. The relative effectiveness of the kerosene extracts was similar to that of the acetone extracts, and the latter was well correlated with the degree of blue or blue-green color given by the Durham test, which the effectiveness of a sample of Tephrosia can be roughly predicted. The insecticidal results were not well correlated with other chemical determinations. A comparison of kerosene extracts of a sample of derris root (rotenone, 1 percent) with those of a sample of T. latidens (rotenone, 0.4 percent) from Florida showed that 1 part by weight of the derris was equivalent in effect against houseflies to more than 8 parts by weight of the Tephrosia. Tests with acetone extracts against houseflies showed that average commercial samples of derris and cube are about 10 times as toxic as a sample of T. virginiana root (rotenone, 0.3 percent).

The same authors (154) in 1935 compared results of toxicity to houseflies of extracts of six samples of derris root, five samples of cube root, one sample of haiari stem, and one sample of Tephrosia virginiana root with the values obtained on these samples by certain chemical determinations. The quantities of rotenone present in the samples were too low to account for all the toxicity. In more than half the samples the figures by the Gross-Smith test, considered as representing the sum of rotenone and deguelin, agreed with the toxicity value, but in other samples they were lower. Total-extractive values were higher than toxicity, and values based on the methoxyl content of the extract were somewhat closer but were also too high. When an approximate value for toxicerol was subtracted from the methoxyl figures, the results agreed more closely with the toxicity figures in general than did the results of other determinations. It was impossible, however, on the basis of the present results, to recommend unreservedly any one of these chemical determinations as a measure of the insecticidal effectiveness of rotenone-bearing plants.

Jones and Smith (157) in 1936 proposed formulas for calculating from the rotenone and total extractive contents the approximate toxic value to houseflies of samples of derris and cube roots. The toxic value of derris root equals rotenone content plus 0.5 of the rotenoid content; that of cube root is the same except that a factor of 0.4 instead of 0.5 is used. The rotenoid content is the total-extractive content obtained with carbon tetrachloride, benzene, or acetone, minus the rotenone content.

Badertscher (11) in 1936 compared results by the Peet-Grady method and the Campbell turntable method. One sample tested consisted of 90 percent of Deobase and 10 percent of oil of sassafras and carried 1 gm. of rotenone per liter. Results by the two methods (50 tests each) on this sample were as follows:

Method	Flies used	Flies down in 10 minutes	Flies dead in 24 hours	Flies dead in 48 hours
	Number	Percent	Percent	Percent
Peet-Grady	4,785	94	64	91
Campbell	4,859	88	59	89

Badertscher concluded that the Peet-Grady method yielded higher kills on pyrethrum sprays and thiocyanate sprays than did the Campbell turntable method, but the turntable method yielded higher kills on sprays that contained rotenone than it did with straight pyrethrum sprays.

DeBussy et al. (48) in 1936 reported that the housefly was controlled by dusting with derris (rotenone 7 percent, but sprays of derris mixtures containing 0.5 and 1.0 percent of rotenone killed only about half the flies and many were only temporarily incapacitated

Cory, Harns, and Anderson (63) in 1936 reported that pyrethrum and derris dusts had little or no repellent action against the housefly under conditions of forceful tropism. The housefly was less susceptible to the toxic action of pyrethrum and derris dusts than was the stablefly.

According to Van der Laan (166) in 1936, the housefly is somewhat sensitive to derris.

LePelley and Sullivan (179) in 1936 reported a study of the toxicity of rotenone and pyrethrins, alone and in combination, to houseflies, when tested by the turntable method. Rotenone was from

five to six times as effective as pyrethrins containing pyrethrins I and II in equal proportions, when mortality counts were made at the end of 3 days after treatment. No striking synergistic effect was produced by 50:50 mixtures of these solutions but they appeared to be significantly more effective than had been expected. It was doubtful whether the 25 (rotenone): 75 (pyrethrins) mixtures were more effective than expected. As the results showed that mixtures of rotenone and pyrethrins are compatible, attention was given to sources of rotenonelike insecticides for mixing with pyrethrum extracts for the control of coffee insects in Kenya. A few tests were made of acetone extracts of the leaves, roots, and stems of a sample of Tephrosia vogelii received from Kenya. The effectiveness of these parts decreased in the order named. The extract of the leaves, which contain the largest proportion of toxic materials, exerted an effect equivalent to a rotenone content in the plant material of about 2 percent. The tested sample of T. vogelii foliage was, therefore, about one-fifth as effective as commercial samples of derris and cube.

Murphy and Vandenberg (209) in 1936 compared the action on houseflies of sprays containing rotenone, pyrethrins, and Lethane 384, which contains 50 percent by volume of beta-butoxy-beta'-thiocyanodiethyl-ether. Butyl cellosolve acetate was used to make the chemically pure rotenone soluble in petroleum distillate. The knockdown by the standard Peet-Grady test was determined for solutions containing 1, 2, 3, and 4 percent Lethane 384; 1/4, 1/2, 3/4, and 1 pound of pyrethrum per gallon; and 0.02, 0.05, and 0.1 percent of rotenone. The results were as follows:

Solution	Knockdown in 10 minutes	Dead in 24 hours
	Percent	Percent
1 percent Lethane 384	98	35
Pyrethrum 1/4 pound per gallon	69	29
Pyrethrum 1/2 pound per gallon	85	45
Pyrethrum 3/4 pound per gallon	89	56
Pyrethrum 1 pound per gallon	92	67
Rotenone 0.02 percent	74	47(48 hours)
Rotenone 0.05 percent	96	56 (do.)
Rotenone 0.1 percent	98	67 (do.)

Two percent of Lethane 384 caused a knock-down of 100 percent in 4 minutes; 3 percent, 100 percent in 3 minutes; and 4 percent, 100 percent in less than 3 minutes. A combination of 2 percent of Lethane 384 and 0.5 pound of pyrethrum yielded a knock-down of 100 percent in 3 minutes, that is, slightly faster than the 2-percent solution of Lethane 384 alone, and much faster than 1 pound of pyrethrum alone. Two-percent Lethane 384 plus 0.05 percent chemically pure rotenone makes a spray causing 100-percent knock-down in less than 4 minutes, or is practically equal to 2-percent Lethane 384, and much faster than any of the rotenone solutions used alone. The data on the killing power of these sprays show that the substitution of part of the pyrethrum or of the rotenone with relatively small percentages of the Lethane 384 not only greatly increases the knockdown power but also increases the killing power. The mixture of Lethane 384 and rotenone gave a kill of 83 percent in 48 hours.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (290) in 1936 reported that suspensions of the powdered roots of certain rotenone-bearing plants and extracts of these plants were outstanding in their effectiveness against the eggs of the housefly.

H. E. Whitmire, of the Whitmire Research Corporation, in a letter to R. C. Roark, dated February 24, 1936, said that a series of rotenone derivatives ranging in melting point from 120° to well over 200° C. had been prepared. The one melting at 178° is called Rotoxlene. Rotoxlene in concentrations ranging from 15 to 100 mg. per 100 cc. in a mixture of ethylene dichloride 5 percent, pine oil 5 percent, and kerosene 90 percent gave knock-downs according to the standard Peet-Grady method ranging from 27 to 96 percent in 10 minutes and final kills ranging from 27 to 95 percent at the end of 48 hours. A screen painted with a solution of 1 pound of Rotoxlene in 100 gallons of oil (0.12 percent) killed every fly that came in contact with it. In a letter dated April 14, 1936, Whitmire reported that at a concentration of 50 mg. per 100 cc. of a 50:50 by volume mixture of ethylene dichloride and pine oil, Rotoxlene gave a knock-down of 92 percent in 10 minutes according to the standard Peet-Grady fly spray test; also 92 percent dead at the end of 48 hours.

Worsley (327) in 1936 dusted the powdered bark of Mundulea upon houseflies. The flies were dead after 10 to 12 hours, whereas pyrethrum killed in 8 hours. Derris containing 5.4 percent of rotenone acted similarly. Kerosene extracts (10 percent) of Mundulea bark had a strong repellent action on houseflies. Several hours later dead flies could be picked up.

Badertscher (12) in 1937 reported that in order to ascertain the true value of a semiconcentrate or a high-kill spray the material should be diluted to such a concentration that its killing power will fall somewhere near the 50-percent kill mark or at least should closely approximate that of the O. C. I. (Official Control Insecticide) of the National Association of Insecticide and Disinfectant Manufacturers. The O. C. I. contains about 90 mg. of pyrethrins

per 100 cc. and gives a kill of 50 to 60 percent by the Peet-Grady method. High-kill sprays were prepared in accordance with formulas published in conjunction with an invitation for bids from the insecticide industry. These samples were prepared in accordance with specifications N. Y. G. D. No. 334-B, November 20, 1935. Under Section V, No. 2, there were set forth specifications for three different combination sprays as follows:

1. Not less than 0.3 percent of pyrethrins and 0.1 percent of rotenone. Derris extractives were permissive if the insecticide thereby contained not less than 0.1 percent of rotenone.

2. Not less than 0.3 percent of pyrethrins and aliphatic thiocyanates corresponding to a content of not less than 0.78 percent of thiocyanoacetic acid (approximately 2.5 percent Lethane.)

3. Aliphatic thiocyanates corresponding to a content of not less than 2.34 percent of thiocyanoacetic acid (approximately 7.5 percent Lethane) plus 0.1 percent of rotenone. Derris extractives were permissive if the insecticide thereby contained not less than 0.1 percent of rotenone.

These sprays all gave better than 90-percent kill of houseflies, which places them in the class of sprays containing 400 mg. of pyrethrins per 100 cc. Rotenone was added as a 1 gm. per 100 cc. solution in camphor-oil sassafrassy.

The Dow Chemical Company (77) in 1937 announced that it had prepared beta-(p-tertiary-butyl-phenoxy)ethanol, called Fly Toxic K-58. A 3-percent solution of this in oil gave a knock-down of 91 percent in 10 minutes and a kill of 45.5 percent in 48 hours by the Peet-Grady method. When 0.075 percent of rotenone is added to this the knock-down is raised to 99 percent and the mortality in 72 hours to 92.2 percent. Para tertiary butyl phenoxy ethanol is stated to be an excellent solvent for rotenone. Solutions in the base oil show no tendency for the rotenone to crystallize. This compound is also a stabilizer for rotenone.

Simanton (252) in United States Patent 2,089,766 issued in 1937, claims an improved insecticide comprising in stable admixture a petroleum fraction, a substance chosen from the class consisting of ethylene glycol monethyl ether acetate and diethylene glycol monoethyl ether acetate, pyrethrins, and at least one of the active toxic ingredients of derris and cube. Among the solvents that have been employed as blending agents in combination with petroleum naphthas are: Ethylene dichloride, carbon tetrachloride, acetone, camphor -sassafras oil, benzol, and chloroform. These solvents all objectionable for a variety of reasons, chief of which is that their odor is distinctly disagreeable. Ethylene glycol monoethyl ether acetate and diethylene glycol monoethyl ether acetate are each completely miscible with the petroleum fractions known as naphthas, and are also miscible to a more limited extent with higher -boiling petroleum fractions.

Simanton said:

> In one actual embodiment of the invention I prepared such a solution by first forming a 5-percent solution of crystalline rotenone in diethylene glycol monethyl ether acetate and then adding 1 part of this solution to 100 parts of a petroleum naphtha extract of pyrethrum flowers prepared by extracting 1.2 pounds of pyrethrum flowers with a deodorized petroleum naphtha. The resulting product was a stable, nonvolatile, substantially odorless solution of excellent insecticidal properties. When tested according to the Peet-Grady method, the solution repeatedly gave a knock-down value of 98 and a kill of 85.

Sullivan (266) in 1937 reported that an increase in concentration of pyrethrins in semiconcentrate fly sprays of pyrethrum at first brought about a corresponding increase in toxicity to houseflies, but at higher concentrations the mortality curve leveled off. When samples of pyrethrum of different pyrethrin concentration were diluted to the same concentration, the mortality of the flies was nearly the same in all cases. Semiconcentrate fly sprays containing paired combinations of rotenone, an aliphatic thiocyanate, and pyrethrins, when undiluted gave almost equally high mortalities in 3 days, but when diluted with 2 parts of kerosene there was a wide range in kill. A comparison of the mortalities at the end 1, 2, and 3 days showed the desirability of a 3-day observation period when the spray contains rotenone. It seems, therefore, that the best method for the biological testing of semiconcentrate fly sprays is to dilute them and compare them with a standard. Pyrethrins (0.3 percent) plus rotenone (0.1 percent) gave a higher kill than pyrethrins (0.3 percent) plus an aliphatic thiocyanate (2.5 percent) or than rotenone (0.1 percent) plus an aliphatic thiocyanate (7.5 percent). The action of the pyrethrins and the aliphatic thiocyanate, when used alone, was complete over a 24-hour period, producing death or a complete recovery of the flies, whereas rotenone is a slow-acting poison requiring a 3-day observation period. For this reason mortality counts were made at the end of the first, second, and third days.

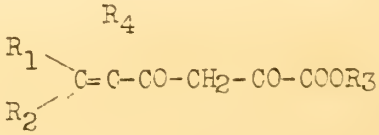
Roark (241) in 1938, in a review of the comparative insecticidal value of derris and cube of equal rotenone content, referred to the work of Jones and Smith (157) and of Campbell, Sullivan, and Jones (53), who tested extracts upon the housefly and reported derris to be superior to cube.

Sullivan, Phillips, and McGovran (268) in 1938 reported that an extract of the fruit of the Amur cork tree (Phellodendron amurense) showed considerable toxicity when tested against the housefly, being about as toxic as derris containing 5.2 percent of rotenone.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Division of Control Investigations (294) in 1938 reported that a petroleum ether extract of derris (I. D. No. 3007) dissolved in kerosene applied as a spray to adult houseflies killed 90 percent after 72 hours. Another petroleum extract of derris (I. D. No. 3354) in kerosene killed 86 percent after 72 hours.

Bliss (34) in 1939 published a discussion of the toxicity of insecticides applied jointly. From a study of the dosage-mortality curves for several mixtures containing fixed proportions of the ingredients, preferably in comparison with equivalent curves for the isolated active ingredients, most cases of combined action can be classified into one of the following three types: (1) That in which the constituents act independently and diversely, so that the toxicity of any combination can be predicted from that of the isolated components and from the association of susceptibilities to the two components. (2) That in which the constituents act independently but similarly, so that one ingredient can be substituted at a constant ratio for any proportion of a second without altering the toxicity of the mixture. With homogeneous populations, dosage-mortality curves for the separate ingredients and for all mixtures should be parallel. Mixtures in this category are more toxic than in the preceding class where association may range from 0 to 1. (3) Synergism forms the third type of joint action, characterized by a toxicity greater than that predicted from studies on the isolated constituents. The log LD50 of ether extract for six samples of derris root was related to the percentage composition of two components in the extract, rotenone (A) and dehydro mixture (B). Since the toxicity of extract could be expressed almost entirely in terms of these two constituents they were then related to each other by the second method. None of the samples contained a very small proportion of one ingredient, so that several equations were equally applicable, one of them being $(1+0.714A)\ B=56.1$, from which the intensity of synergism was 40.

Kilgore (160) in United States Patent 2,149,917 issued in 1939, claims a process which comprises the extraction of rotenone and other compounds having insecticidal properties from rotenone-bearing plants by means of an ester belonging to the class of organic compounds known as delta-epsilon-unsaturated-alpha-gamma-diketo carboxylic esters of the general formula:



wherein R_1 and R_2 are the same or different organic radicals or respectively one organic radical and one hydrogen atom, R_4 is an alkyl radical or a hydrogen atom, and R_3 is any organic radical forming an ester of the carboxyl group. Not only do these esters effectively extract rotenone from such plants but they carry the extracted rotenone into solution in sprayable vehicles, such as hydrocarbon solvents, thus effecting a direct transfer of the rotenone from the plant to the final insecticide solution. Tests against houseflies were made with extracts

prepared by forming a paste or heavy dispersion of powdered derris root in the ester wherein 10 parts of the root were admixed with 25 parts by weight of the ester. This mixture was then heated at 100° C. for 1 hour. The extract was removed by filtration, yielding in most cases extracts having straw-yellow to brown-red color. Four-percent solutions of each of the extracts were then made using a deodorized kerosene solvent suitable for insecticidal tests and filtered whenever necessary. The insecticidal effects of these solutions were then compared to that of similar concentrations of the esters alone by bio-assays, using houseflies under identical controlled conditions. The results of these tests are shown in the following table.

Esters used as extractants	Pure ester only	Ester and extracted rotenone
A. Derris root extractions	Percent	Percent
Mesityl oxide oxalate, ethyl ester	9	100
Mesityl oxide oxalate, n-butyl ester	30	100
Mesityl oxalate, iso-butyl ester	16	100
Mesityl oxalate, sec-amyl ester	53	100
Mesityl oxide oxalate, cyclohexyl ester	17	100
Mesityl oxide oxalate, tetrahydrofurfuryl ester	4	85
Acetalacetone oxalate, n-butyl ester	80	100
n-Butyralacetone oxalate, ethyl ester	6	95
3-Methyl-3-pentene-2-one oxalate ethyl ester	45	85
3-Methyl-3-heptene-2-one-oxalate, ethyl ester	2	100
Tetrahydroacetophenone oxalate, ethyl ester	4	98
B. Tephrosia virginiana root extraction		
Mesityl oxide oxalate, n-butyl ester	30	67
C. Cube root extraction		
Mesityl oxide oxalate, n-butyl ester	30	62

The bio-assays were made with 5-day-old houseflies, caged in 5-inch by 5-inch, cylindrical, all-wire cages, using approximately 100 flies to the cage. Each cage was separately exposed to the same amount of finely atomized spray or fog from which the larger droplets had been removed, by using an L-shaped pipe, 6 inches in diameter and 1 foot long on each side of the elbow, mounted with one side of the L in a vertical position. The cage of flies was then suspended in the top of the upright pipe and the atomizer was placed at the other end of the L. Five cubic centimeters of the diluted ester of the extract was then atomized into the pipe at the bottom end, producing a highly dispersed, smokelike fog, which was driven evenly throughout the cage. The cage was then removed and set aside for 24 hours, when the number of "dead" was determined--the term "dead" including flies that were paralyzed and unable to feed after 24 hours.

Pierpont (235) in 1939 reported that the insecticidal action of solutions containing 50 and 100 mg. of rotenone, respectively, per 100 cc. and 7.5 percent of safrol in a petroleum-oil base was increased by the addition of 2.5, 5.0, 7.5, and 10.0 percent of D. H. S. Activator (ethylene glycol ether of pinene). The increases were less then with pyrethrum fly sprays, approximating 5 percent for each 2.5 percent of activator added. The 24-hour mortality for rotenone fly sprays was increased by the addition of D. H. S. Activator, without any significant reduction in the 24-to 48-hour mortality characteristic of them. As with pyrethrum fly sprays D. H. S. Activator reduced the knock-down time of the rotenone-safrol combinations in relation to the amount added; that is, the more Activator, the quicker the knock-down. Fly sprays of rotenone (100 mg. per 100 cc.) and safrol (7.5 percent) in a petroleum-oil base and these same sprays containing various amounts of D. H. S. Activator were stored in airtight tin cans at room temperatures ranging from 70°-80° F. and likewise exposed to heat (a constant temperature of from 100°-105°) for 8-1/2 months without any significant loss in toxicity or reduction in the activation effect.

The loss in the toxicity of fly sprays containing rotenone, safrol, and D. H. S. Activator, when exposed to sunlight and light in flint-glass bottles, is correlated with color changes and precipitation. Although disintegration apparently takes place more rapidly than with the rotenone and safrol alone, the Activator functions in maintaining such sprays at a relatively high toxic level. Ethylene glycol ether of pinene (D. H. S. Activator) is an effective activator for both pyrethrum and rotenone and can be safely and economically included in commercial fly sprays.

Sievers and Sullivan (251) reported in 1939 that they used the housefly in the turntable method for evaluating different extracts of the root of devil's-shoestrings (Tephrosia virginiana). Acetone and chloroform were equally effective in extracting the active principles, and heating the extracts did not decompose them.

Sullivan, McGovran, Feles, and Goodhue (267) in 1939 reported that the smoke formed by spraying a solution of rotenone in safrol

or acetone against a hot plate (400° C.) was very toxic to houseflies. An oleo-resin containing 25 percent of pyrethrins, alone and in combination with rotenone, also gave very good results. This method of application of rotenone has many advantages over other methods: (1) The smoke containing rotenone is very stable; (2) it is not readily adsorbed on surfaces such as walls or floors; (3) it has high efficiency in respect to amount of material used and amount of solvent required; (4) it is probably less dangerous to the health of plants; and (5) it is easily confined, as compared with most other fumigants.

Allen and Brooks (9) in 1940 reported the results of a detailed study of the effect of alkalinity on rotenone-bearing dusts made by testing kerosene extracts of the dust mixtures on houseflies. The diluents tested ranged in pH from 4.23 for calcium sulfate to 12.5 for hydrated lime. Powdered derris, timbo, and barbasco were mixed with the diluents in the ratio of 1:9. It was concluded that rotenone-bearing dusts prepared from highly alkaline diluents, and kept in damp storage without light for 7 days, exhibited little or no change in pH, but showed considerable loss in toxicity when used in kerosene extracts in tests with houseflies. Parallel samples of acid dust, kept under identical storage conditions, retained their toxicity. Dry or unmoistened alkaline and acid samples remained unchanged. The addition of sulfur to the alkaline dust mixtures prevented deterioration of the rotenone-bearing dust mixtures under the conditions of this experiment.

Goodhue and Sullivan (119) in 1940 reported on toxicities to the housefly of smoke from derris and pyrethrum. The effect of the smoke from a burning mixture consisting of 50 percent of derris, 30 percent of cornstalks, and 20 percent of sodium nitrate was tested against the housefly. The tests were made by exposing the flies in cages in a Peet-Grady chamber for 1 hour at 25° to 29° C. Derris smoke was more than 10 times as toxic as the smoke from pyrethrum burned in the same way. The presence of rotenone in the smoke, even after 1 hour, was demonstrated by the Goodhue red-color test. The derris mixture at 4 ounces per 1,000 cubic feet killed 95 ± 1.7 percent of the flies in 72 hours.

Mironoff et al. (206) in 1940 reported tests with derris against the housefly. The mortality was about 97.6 percent when pyrethrum was used in dosages of 2 gm. in 1 cubic meter, whereas derris gave 97.8 percent kill under the same conditions, with only one-twentieth of the dosage used for pyrethrum. The action of derris is slower than that of pyrethrum. The paralysis caused by derris is fatal to the fly, whereas the paralysis caused by pyrethrum does not always result in a kill.

Sievers et al. (250) in 1940 reported on the changes in the insecticidal value of the roots of cultivated devil's-shoestrings at 4 seasonal growth periods. For the toxicity tests made on the housefly by the methods of Campbell and Sullivan, acetone extracts

were made by shaking the sample with acetone for 7 hours, using such proportions that each cubic centimeter of the filtered extract represented 0.2 gm. of the plant material. Only one determination was made of each sample each day. The materials were applied as an acetone spray at a concentration of 8 mg. of plant material per cubic centimeter of solvent. Six tests were made, each on 38 samples. Each set of 38 consisted of composite samples from several progenies of each of the 10 parent plants from each of the 4 growth stages, except that in 2 cases material was not available. Clonal progenies of 10 parent plants of Tephrosia virginiana were grown under cultivation in northeastern Texas to study the changes in the amount of rotenone and chloroform extractive present in the roots of such progenies and their toxicity to houseflies at 4 seasonal stages of growth. The roots were dried and ground, the amount of chloroform extractive and rotenone determined, and the toxicity of acetone extracts tested on houseflies. The results indicated that at the full-bloom stage the roots were significantly more toxic to houseflies than at the dormant and emergencestages, but their superiority over those at the mature-seed stage was less pronounced. The chloroform extractive and rotenone content was also highest at the full-bloom stage. The toxicity of the roots of the several clonal progenies of the same parent did not vary significantly, but significant differences were found in this respect between the progenies of different parents.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Division of Control Investigations, (29) in 1940 reported that rotenone in safrol (20 mg. per cubic centimeter, dispersed by dropping on a hot plate, caused 15-percent knock-down of houseflies in 10 minutes, and killed 65 percent in 2 days and 83 percent in 3 days.

The Whitmire Research Corporation (319) in 1940 published an account of repellency tests against houseflies. A series of repellent walk tests developed by Whitmire and Denny, at St. Louis, Mo., has demonstrated the effectiveness of this method in checking the toxic and repellent values of contact insecticide sprays. The test was conducted by painting 125 mg. of spray on 8.75 square inches around the top of the arc of a circular screen roach-cage. The base of the cage was a funnel which extends into the observation cage. Flies so affected with leg paralysis that they cannot fly or walk fell through the small opening at the bottom of the funnel into the observation cage, where they had access to food and water. The funnel opening could be kept closed by a cork stopper in order to record the percentages of knock-down at definite time intervals. The livestock spray used was a 10-percent solution of a mixture of tephrosin, deguelin, sumatrol, toxicarol, and other highly toxic unidentified substances extracted from derris resins. The cage was painted 1 hour before the flies were introduced and the following average results were recorded: After 10 minutes 36 percent were down; after 30 minutes 74 percent were down, at one hour 98 percent were down, and at the end of 24 hours 99 percent were dead.

Stomoxys calcitrans (L.), the stablefly

The Maryland Agricultural Experiment Station (196) in 1935 reported that progress had been made on the general insecticidal project in the study of pine oils, pyrethrum, and rotenone as repellents.

Cory, Harns, and Anderson (63) in 1936 reported that pyrethrum and derris dusts had little or no repellent action under conditions of forceful tropism, and that the protection given cattle by pyrethrum and derris dusts was obtained through the toxic action of the materials. The stablefly was more susceptible to toxic action of pyrethrum and derris dusts than the housefly. Pine oil increased the toxic action of the derris dusts, which have a relatively low initial toxic rating. Pyrethrum-impregnated dusts afforded more protection per unit cost than the derris-impregnated dusts, but the derris-impregnated dusts were more toxic per unit.

E. W. Laake, of the Dallas, Tex., laboratory of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in a typewritten report in 1936 to the Division of Insects Affecting Man and Animals, stated that powdered cube root, rotenone concentrate, and many other materials were ineffective as repellents.

Doty (76) in 1937 reported on insecticidal tests conducted on both wild and reared Stomoxys flies by the Peet-Grady method, using aliphatic thiocyanate (Lethane 384), pyrethrum, and rotenone sprays. These flies were found to be considerably less resistant than houseflies. Field and laboratory repellency tests showed that Stomoxys flies were repelled by these sprays to about the same extent as are houseflies; therefore, data obtained from repellency tests on houseflies with these materials are also applicable to the Stomoxys.

Mycetophilidae

Lycoria pusilla (Meig.)

An anonymous (6) writer in 1937 stated that derris was ineffective.

Lycoria praecox Meig.

Symes (269) in 1921 reported that pure derris powder applied to a bed of mushrooms infested with the mushroom fly cleared the bed of insects in 2 or 3 days, but had no effect on Hypomyces fungi. It was concluded that mushrooms will not stand treatment with powder insecticides (such as pyrethrum, derris, and 1-percent paradichlorobenzene). When not checked in their growth by these powders, the mushrooms were rendered absolutely unfit for market.

Lycoria sp.

Thomas (272) in 1934 tested derris against mushroom insects.

Rotenone dusts killed some sciarid flies but seemed to be much slower in action than pyrethrum dusts, and heavy dosages of proprietary rotenone compounds placed in the manure were ineffective against insects there, perhaps because these compounds were affected by the alkalinity of the manure.

Miles and Miles (203) in 1935, in discussing the use of derris for combating greenhouse pests, said that soil or manure infested with eggs or maggots of fungus gnats, Sciara sp., should be treated/bei with some insecticide such as derris or pyrethrum before/taken into the house.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (291) in 1938 stated that tests made against various species of mushroom flies, Sciara sp., in the mushroom houses at Beltsville, Md., with a number of drenches and with derris powder demonstrated that the drenches containing free nicotine or the alcoholic extract of pyrethrum gave the best results as judged by crop yield.

Hamilton (132) in 1939 recommended derris or cube extract sprays as contact poisons for the control of white maggots in the soil around house plants.

Oestridae

Hypoderma bovis (Deg.), the northern cattle grub

See Bishopp et al. (29,32) Case (58), MacDougall (188), De Bussy et al. (48), Wells and Schroeder (313), the United States Department of Agriculture, Bureau of Animal Industry (281), Bureau of Entomology and Plant Quarantine (297), and Wells (311) under Hypoderma lineatum (De Vill.).

Hypoderma crossi Patton, a goat warble fly

See Bhatia (26) under Hypoderma lineatum (De Vill.), on page 51.

Hypoderma lineatum (De Vill.), the common cattle grub

Bishopp et al. (29) in 1926 reported that a proprietary derris extract, 1 part, plus 10 parts of water (containing 4 oz. of soap per gal.), killed 100 percent of cattle grubs when injected with an oil can directly into the grub holes in the backs of the cattle. Derris powder, 8 ounces, plus soap, 4 ounces, per gallon of water, applied twice as a wash on the back, also killed 100 percent of the grubs. Tests with dry derris powder, derris powder with paraffin oil, derris powder with petrolatum, derris powder with soap and water, and derris powder with water only are recorded. The percentage mortality of Hypoderma bovis Deg. was not so high as that of H. lineatum. The authors concluded that tests of the application of washes, powders, and ointments to the backs of the cattle and also

the injection of substances into the cysts containing the larvae show that each of these methods of treatment is effective if certain materials are used. Derris used as a wash, as an ointment, or as a powder is among the most effective of these.

Walton (305) in 1927 reported on the control of warble flies in North Wales. The killing properties of derris appeared to be excellent. The ointment (1 part of derris powder plus 2 parts of soft paraffin) is odorless, and the cost is low. On the other hand, the ointment was found to be much more difficult to apply and olive oil was utilized, the ointment then consisting of 1 part of powdered derris, 1 part of soft paraffin, and 1 part of olive oil. This improved the texture and rendered application easier. Hypoderma lineatum is the predominant species in North Wales.

Case (58) in 1929 reported that six 3-year-old steers in Burkes Garden, Va., infested with ox warbles (Hypoderma lineatum and H. bovis) were treated in March 1927 with derris powder. One animal was treated by removing each scab, then sprinkling on the powder and rubbing it with the finger tips. At the time of the examination, 3 days later, this treatment had killed all 5 larvae in the animal. The other 5 animals were curried over the back, ribs, and loin with a round, spring, stock comb; the powder was sprinkled on by means of a shaker can and rubbed in quickly but thoroughly. This method of application caused a mortality of 24 out of a total of 50 larvae.

MacDougall (188) in 1930 reported details of experiments carried out in Scotland with 5 proprietary dressings for the control of Hypoderma bovis and H. lineatum in cattle. A wash of derris powder and soft soap gave very satisfactory results, killing 2,785 of the 3,035 larvae treated. In mixing the wash, care should be taken that the boiling water in which the soap is dissolved is cooled to blood heat at least before being poured on the derris powder, or the active principle of the latter may be affected.

Little (181) in 1931 reported on the insecticidal properties of the devil's-shoestrings (Tephrosia virginiana). The roots dug from several localities at various times of the year were dried by different methods and then finely ground in an herb mill. Encouraging results were obtained on common cattle grubs.

Later Little (182) reported in 1931 that the powdered root of Tephrosia virginiana dusted on cattle grubs in the backs of cattle killed about 90 percent within 10 days.

Bhatia (26) in 1934 reported that the goat warble fly (Hypoderma crossi Patton) and the cattle warble fly (H. lineatum (De Vill.)) do great damage to goat skins in India. Reference is made to the successful use of derris and Polvo against warble grubs in England.

DeBussy et al. (48) in 1936 reported that Hypoderma bovis and H. lineatum can best be controlled by washing the animals with a suspension of derris in water.

Wells (309) in 1937 submitted the following table showing results of preliminary tests at Colorado Springs, Colo., in which rotenone, derris powder, and devil's-shoestrings were used against larvae of Hypoderma lineatum encysted in the backs of cattle.

Method of treatment	Composition of solution				Animals treated	Larvae treated	Larvae surviving	
	Oil	Cresol	Benzol	Rotenone				
	Cc.	Cc.	Cc.	Gm.	Number	Number	Number	Percent
External	45	5	50	3.0	14	317	10	3.15
Injection	45	5	50	1.0	4	115	7	6.08
Do.	70	5	25	1.5	2	52	4	7.67
Do.	70	5	25	0.5	9	211	11	5.21
Do.	70	5	25	1.0	20	234	17	7.26
Do.	70	5 Cresol compound	25	0.5	7	135	15	11.11
Do.	45	5 Cresol compound	50	0.5	10	202	31	15.34

Four animals were treated externally with undiluted devil's-shoestrings (1.72 percent rotenone) at the rate of 3 ounces per animal, with the result that of the 288 encysted larvae 250, or 86.8 percent, survived. On one animal, given an external application of 3 ounces of undiluted derris powder (3 percent rotenone), 51.11 percent of the 90 encysted larvae survived.

R. W. Wells, in a typewritten report to the Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in March 1937 on the control of Hypoderma lineatum larvae in the backs of cattle in Colorado, Missouri, and Iowa, stated that in 1934 it was found that a treatment with a solution made up with 70 cc. of paraffin oil, 5 cc. of cresol, 25 cc. of benzol, and carrying 1 gm. of rotenone to each 100 cc. of the composite solvent, was survived by only 5.59 percent of the larvae treated (by injection into the cyst), whereas the same solvent without rotenone was survived by 75.47 percent of the larvae treated. Numerous tests led to the conclusion that 1 gm. of rotenone per 100 cc. of

solvent is about the minimum advisable dilution for external treatment; the external treatment is fully as efficient as the injection; and the inclusion of the other derris resins, in addition to the rotenone, does not add significantly to the efficiency of the preparation. As would be expected, more of the solution was used in the external application than was required for injection. Approximately 400 cc. of the solution was used in treating externally the backs of 14 cattle carrying a total of 317 grubs.

Wells (311) in 1940 published directions for the use of derris and cube washes in the control of cattle grubs. The powder, soap, and water are mixed in the following proportions: Water, 1 gallon; cube or derris powder (5 percent rotenone), 12 ounces; soap, 2 ounces. One gallon of the wash is sufficient to treat the backs of 12 to 16 adult cattle, depending on how long and how thick the hair is.

Wells and Schroeder (313) in 1939 reported on the effectiveness of derris washes on cattle grubs. Washes consisting of 8 and 12 ounces of derris per gallon of water, plus 4 ounces of soap, applied at the rate of 1/3 quart per animal, are less toxic to Hypoderma bovis than to H. lineatum. In the former species the third instars were more resistant to the washes than were the second instars while with the latter species the reverse was true. Hand rubbing of the backs of the animals after application of the insecticide was more effective in killing H. lineatum larvae than was brush rubbing, but in treating animals infested with H. bovis the latter method was just as effective as the former.

The United States Department of Agriculture, Bureau of Animal Industry (281) in 1940 stated that experimental work was continued with washes containing derris powder and cube powder to determine their value and relative effectiveness as larvicides for the common species of ox warbles (Hypoderma lineatum). The washes were prepared just before application and consisted of warm water, soap, and derris or cube powder. The soap, usually in flake form, was added to the warm water in the proportion of 4 ounces to a gallon, and the derris or cube powder in 12 or 16 ounces per gallon. About 1 pint of wash was applied along the back of each animal treated. The liquid was then spread evenly over the back and sides and into the hair coat with an ordinary scrub brush. The experimental cattle were located in Texas, New Mexico, Colorado, and Missouri. They were infested with grubs of H. lineatum. Grubs of H. bovis Deg. were not found in any of the cattle. The cattle were treated when grub openings began to appear in their skins. Derris and cube powders were equally effective as larvicides for cattle grubs. The powders containing 4 percent of rotenone, used in the proportion of 12 ounces to a gallon, were as effective in killing grubs in situ as those containing 5 percent, when used in the proportion of 16 ounces to a gallon, but the former was not so effective as the latter in killing grubs that came up after treatment was applied. In most cases more than one treatment was necessary to eradicate the grubs. Some treatments

were applied when the outside temperature was as low as 20° F., but, although the cattle were exposed to cold, inclement weather, no injury was detectable.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (297) in 1941 called attention to the presence of both the common and the northern cattle grubs in northern Colorado and across Wyoming, and to a demonstration of their control with cube wash at a ranch near Parkman, Wyo. It was planned to treat about 15,000 head of range cattle for cattle-grub control.

Hypoderma sp.

In December 1916, Lemmens and Fryer applied for certain British (173) and German (176, 177) patents covering the use as insecticides of powder and extract of Tephrosia, particularly mentioning T. vogelii. The patentees stated that the purpose of the invention was to provide improved means for the destruction of insects, vermin, and similar parasites of various animals and plants, such means being suitable for ready use as an insecticide powder or wash for spraying upon plants, trees, and other vegetable growth, and upon soil, and as a sheep dip, a cattle dressing, or a wash for animals, whereby the parasitic pest could be destroyed without injury to the plant or animal life. In 1917 Lemmens and Fryer (174, 175) applied for and were granted United States patents covering the same invention.

Bishopp, Laake, and Wells (30) in 1922 stated that a single application of derris in soapy water applied with a brush to the backs of infested animals killed almost 100 percent of Hypoderma larvae.

Wells, Bishopp, and Laake (312) in 1922 reported that an ointment consisting of 1 part of derris to 2 parts of vaseline, applied to warble holes in the backs of cattle, was as effective as any other material used in this way. Five days after treatment all grubs were found to have been killed and the condition of the cysts was very satisfactory. A wash consisting of 1 pound of derris, 4 ounces of soap, and 1 gallon of water, applied once with a brush to the backs of infested cattle, killed practically all grubs.

Hadwen (130) in 1923 referred to the killing of Hypoderma larvae by the application of derris to the warble holes.

Bishopp, Laake, and Wells (31) in 1929 reported that for the control of cattle grubs in the backs of cattle an ointment consisting of powdered derris root, 1 part, and petroleum, 10 parts, gave excellent results. Fine derris powder was very effective. As a wash, derris powder 1 pound, water 1 gallon, and soap 2 ounces briskly rubbed in with a brush gave a 100-percent kill in many cases. A pound of derris powder is sufficient for a general application to the backs of 20 to 25 head of cattle.

Bishopp, Laake, Wells and Peters (32) in 1930 reported that excellent results were obtained in tests made against Hypoderma larvae in the backs of cattle by the use of powdered cube root, powdered derris root, derris extract in kaolin, derris resins in petrolatum, and a proprietary derris-extract ointment. No toxic effects on the cattle are to be expected from derris products and they do not seem to injure the skin. Derris powder from which the rotenone had been partially extracted with ether killed 33 percent of the grubs, indicating that the other constituents have insecticidal value. Kaolin containing not less than 2 percent of rotenone gave almost a complete kill.

Bishopp (28) in 1941 reported that, for killing cattle grubs, derris powder should obtain at least 1 percent of rotenone and should be ground fine enough to allow 90 percent of it to pass through a 200-mesh sieve. Although apparently not so effective as ground derris root, certain powders to which from 1 to 2 percent of rotenone or a proportionate amount of derris extract had been properly added were satisfactory. A wash consisting of derris powder 1 pound, water 1 gallon, and soap 2 ounces, briskly rubbed in with a brush, gave a 100-percent kill in many cases.

The United States Department of Agriculture, Bureau of Entomology (282) in 1923 reported the work of Bishopp et al. Over 98 percent of the grubs can be killed with a general application of powdered derris root to the backs of cattle. A wash consisting of 1 pound of derris, 4 ounces of soap, and 1 gallon of water also gave a kill above 96 percent. An ointment consisting of 1 part of derris and 5 parts of vaseline gave almost 100-percent kill when the material was pressed (283) into each hole. The same Bureau in 1927 reported that tests with insecticides against cattle grubs in Virginia indicated that powdered derris root will give a high percentage of kill if applied and brushed in at intervals of about 20 days. The Bureau (284) in 1929 referred to experimental work done with insecticides applied to the backs of cattle, special attention being given to rotenone and other materials extracted from derris root. The report stated that these insecticides show high toxicity to cattle grubs and can undoubtedly be developed to a point where they can be extensively used in control work. In 1930 the Bureau reported that 2 or more ounces of derris powder per animal are necessary if the entire back of each animal is to be treated. The Bureau (286) in 1931 stated that derris and its derivatives appeared to be the most promising insecticides for the control of cattle grubs, particularly as there is no danger of (288) poisoning livestock with them. In 1933 the Bureau reported that various insecticides for killing the grubs in the backs of cattle by hand application had been tested. Rotenone, in combination with benzol, was found to be highly efficient. One-half gm. of rotenone was dissolved in 100 cc. of benzol, and approximately 1 cc. of the mixture was injected into the opening of each cyst. This method of treatment is relatively fast, as compared with any other treatment applied to grubs individually.

Wardle and Buckle (307) in 1923 referred to the derris wash recommended by Wells, Bishopp, and Leake in 1922 for killing Hypoderma

larvae in the backs of cattle.

MacDougall (185,186) in 1924 reported tests with a proprietary preparation of derris. Any scab and matted hair obscuring the exit hole of the larva in the skin was cleared away before the dressing was applied. One ounce of derris to 1 imperial quart of water killed 86 percent, and 1 ounce to 1 pint killed 94 percent of the warbles. No injurious effects attended any of the cattle dressed with derris and there was no discomfort to the hands of the dresser. MacDougall (187) in 1928 reported that two dressings of service against Hypoderma larvae, tested in Scotland in 1927, averaged good results. The first was one in great favor in Denmark, viz., Hypoderma oil. This costs 5 pounds per gallon, but a little goes a long way. It was injected by means of a syringe at the opening into the warble, the squeezed hole being first cleared. Three or 4 days later the treated warbles were examined and the larvae were out. While Hypoderma oil did not do all the advertisements claimed for it, it can be recommended. It was most successful against the younger larvae. Last-stage larvae were much more difficult to kill. Treated cattle did not suffer in health, and there was no falling out of hair. MacDougall, (188) in 1930 reported that Kur-Mange at 1 ounce per imperial quart of water killed 86 percent of Hypoderma larvae in the backs of cattle, and at twice this concentration killed 95 percent.

MacDougall (189) in 1931 reported on the campaign against ox-warble flies in Scotland in 1930. The following derris preparations were effective against the larvae: Polvo powder 1 pound, soft soap 1/4 pound, water 1 imperial gallon; Warble Fly Powder 1 pound and water 1 imperial gallon. In 1932 he (190) reported that in Scotland in 1931 three different kinds of dressing were tested, viz.: Polvo soft soap as in 1930; Warble Fly Powder (with the soap already incorporated and needing only the addition of water): and a liquid derris preparation. The first two were very successful. MacDougall (191) in 1934 reported tests on control work in Scotland with the following proprietary derris products: Bovidera oil, Cooper's Warble Fly Ointment, Cooper's Warble Fly Powder, Cooper's Cattle Wash, and Polvo. Ninety-three percent of the warbles were killed 8 days after the application of Polvo powder soap wash containing derris powder 1 pound, soft soap 1/4 pound, and water 1 imperial gallon, at the rate of 3/4 gallon per animal. The cost of material was about 2 cents per animal per application, and the total cost was about 25 cents per animal for 4 applications. Tests were also made with cube powder. Using the proportions 1/4 pound of the powder to 1 imperial gallon of water, 43 warbles were dressed and on examination, 25 larvae were dead, 5 were alive, and 13 burst in being squeezed out. Using 1/2 pound of the powder to 1 imperial gallon of water, 42 larvae were treated and on reexamination 30 larvae were dead, 1 was alive, and 11 burst in being squeezed out.

Walton (304) in 1925 reported that preliminary trials of derris ointment prepared according to the formula of Wells, Bishopp, and Laake had been made for the control of warble flies in North Wales. The results obtained with 91 cattle were most promising.

Field (88) in 1926 reported that the derris product Kurmange, 1 ounce to an imperial quart of water, killed 86 percent of Hypoderma larvae,, and at 2 ounces per quart it killed 95 percent. Cattle dressed with Kurmange suffered no injurious effect.

Blieck and Baudet (33) in 1927 reviewed the work of Bishopp et al. (29) on derris against ox warbles.

Leynen (180) in 1928 reported that the "Commission Hollandaise du Varron" recommended the use of derris powder for destroying Hypoderma larvae, as recommended by Bishopp et al. (29) in 1926.

Metcalf and Flint (202) in 1928 recommended derris as a wash for killing ox warbles in the backs of cattle.

C. H. Richardson (238) in 1928, in a review of isecticides, stated that derris had given excellent results in the control of cattle grubs.

Warburton (306) in 1929 referred to the action of the Leathersellers' Company in appointing a committee to consider the whole question of the warble fly on cattle, and this committee's recommendation of a derris soap wash, consisting of 1 pound of powdered derris root, 1/4 pound of soft soap, and 1 imperial gallon of water.

Gaut (99) in 1929 outlined a plan to kill all warbles in cattle within a given area of Worcestershire County, England, by the use of a wash made according to the following formula: Standardized derris powder, 1 pound; soft soap, 1/4 pound; and water, 1 imperial gallon.

Gaut and Walton (103, 104) in 1929 reported that the use of a derris-soap wash made according to a formula recommended by Bishopp/gave et al./pronounced success against ox warbles and was, moreover, a fool-proof remedy. It was made up as follows: Polvo (derris powder) 1 pound, soft soap 1/4 pound, water 1 imperial gallon. The soft soap was boiled in about 1 quart of water. After cooling somewhat it was gradually poured on the dry powder that had been previously placed in a small bucket or can, and mixed by means of a wooden stirrer into the consistency of mud; enough cold water was then added to make up 1 gallon of wash. It was applied with a soft cloth, wetting the warble lumps thoroughly. The wash should be frequently agitated to prevent sedimentation. Warble Fly Ointment, a derris product made by Cooper, McDougall, and Robertson, Berkhamsted, England, gave a 100-percent kill when forced into every warble hole.

Gaut (100) in 1930 reported on experiments with derris against the ox warble fly in Worcestershire County, England. The insecticide was standardized derris powder (Polvo), used according to the formula of Bishopp's et al. (30). Replies to a questionnaire ihdicated that 232 out of 244 farmers considered that the derris-soap wash had been satisfactory for killing warbles. Tests in 1930 indicated that a half-strength wash gave 100-percent kill of warbles at each of the 4 applications. Experiments have proved that both the full-strength and half-strength washes, used 28 days and 56 days after preparation, are just as effective as freshly made material.

Gaut (101) in 1931 reviewed the results of tests in 1928-31 in the same county. The derris-soap wash (Polvo 1/2 lb., soft soap 1/4 lb., and water 1 imp. gal.) was used successfully in 15 areas, on more than 10,000 head of cattle on nearly 500 farms. He (102) in 1936 called attention to his previous (101) report on derris wash and recommended its application with a 1-gallon short-spouted watering can.

Davies (68) in 1930 described tests with four derris powders and two derris solutions for the control of Hypoderma larvae in North Wales. When it was used as a wash, derris powder from three of the sources proved highly toxic to warble fly larvae under critical, general, and ordinary farm conditions. The powder was applied, according to the formula of Bishopp et al. (30). The wash evidently will not retain its toxicity if kept more than a day or so after it is prepared. Four monthly dressings were proved to be necessary. It was estimated that 1 pound of derris powder is sufficient to provide a wash for 4 monthly dressings for 20 to 25 infested cattle.

Fulmer (90) in 1930 reported that larvae of the warble fly were amenable to derris.

Hollstein (141, 142) in 1930 described tests with Kur-Mange, a powder containing dried soda soap, borax, unknown constituents, and rotenone extracted from Derris elliptica. When used at the rate of 10 gm. per 200 cc. it was useful for combating warble fly larvae when applied by injection. Kur-Mange at 31 gm. to 550 cc. of water killed 95 percent of the larvae in tests made in England. Cooper's Warble Fly Salve (Dasselfliegensalbe) is useful for combating warble fly larvae when applied by injection.

Jensen (152) in 1930 mentioned derris extract as one of the preferred preparations for the treatment of cattle grubs in Jutland.

The University College of North Wales, Department of Agriculture (219), in 1930 stated that in Great Britain the annual loss caused by warble holes in hides is estimated to be more than 500,000 pounds sterling. A derris wash made according to the formula of Bishopp et al. (29) is recommended.

Schwerdt (248) in 1930 reported that Kur-Mange and Cooper's Warble Salve (derris preparations) were found to be inconvenient in the treatment of warbles, although in the hands of an experienced man, especially a veterinarian, they could be used with favorable results.

The United States Department of Agriculture in a release to the press on May 25, 1930, reported that cube is fatal to cattle grubs. The derris and cube root powders had no unfavorable effect on the skin and hair of the animals tested and are not particularly poisonous, hence are safe to use. Applications of these powders at 15-day intervals

killed most of the grubs. From two to four treatments were required.

An anonymous (1) writer in 1931 reviewed a report in the Yorkshire Post by R. C. Gaut, Agricultural Organizer for Worcestershire, England, on the value of derris in combating ox warbles. About 10,000 head of cattle were dressed 4 times with a preparation made according to the Bishopp et al. (29) formula. The fine particles carried in the soapy wash during dressing effectively plug the breathing holes of the grubs, causing death by suffocation. There is thus a dual action, which makes a 100-percent kill possible. The wash should therefore be kept well agitated by means of the cloth and hand so that little or no "mud" remains at the bottom of the vessel when the liquid has been used up.

An anonymous (2) writer reported in 1931 that tests made on one animal with the "Derrifluid" of Tropper showed good effect on Hypoderma larvae when the material was injected, but poor results from external application. The injection was easy and without harmful after effects.

Compton (60) in 1931 gave an account of an eradication campaign carried on in Illinois, with Gusanol, a proprietary derris extract ointment. The treatment was started about February 20 and was given at 30-day intervals until about the first of July. It is estimated that this treatment reduced the ox warble population 66 percent.

The Ministry of Agriculture and Fisheries of Great Britain (124) in 1931 estimated the annual loss in Great Britain from hides damaged by warbles at more than 500,000 pounds sterling. Preparations of derris root were very effective in destroying warble larvae. Two proprietary derris preparation were used--(1) an ointment, and (2) a wash prepared from a powder sold as an insecticide. It was claimed that both the ointment and the wash, when carefully applied, would kill practically all the mature or maturing warbles at a cost in materials of about 1 penny per head for the four applications. No harmful effects to the cattle were recorded. When the ointment is used each warble hole must be located and treated after being freed from hair. The wash is more convenient to apply, as it is only necessary to locate the swellings and then liberally wet each one with a soft cloth steeped in the preparation.

Zaubzer (330) in 1931 reported on warble fly control in Bavaria. Mechanical removal has given better results than any other method, including Hypodermol, a largely used salve containing paradichlorobenzene, derris, and laurel oil.

The University College of North Wales, Department of Agriculture (220) in 1931 repeated its recommendations of 1930 for warble fly control by means of derris.

Reisinger (236) in 1931 recommended the following proprietary derris products for warble control: Cooper's Salve, Derrifluid,

Hypodermol, and Kur-Mange.

An anonymous (3) writer in 1932 gave an account of an exhibit at the Royal Dublin Show by the Educational Section of the Irish Free State Department of Agriculture, showing the damage to hides caused by warbles. Samples of derris root, derris powder, and the derris wash ready for use against ox warbles were shown by the Irish representatives of Cooper, MacDougall and Co., with the slogan "Cattle dread the warble fly. The warble dreads derris powder. Rub it into him."

Campbell (50) in 1932 reviewed unpublished work of Wells, who tested rotenone for the control of the common cattle grub. He applied to the backs of infested cattle dusts containing 0.5 to 2.0 percent of rotenone and cottonseed oil containing 0.5 percent of rotenone. Best results were obtained with the latter mixture, 94 percent of the grubs being killed in a week. The dusts killed about 75 percent. Wells concluded that thoroughness of application is more important than the percentage of rotenone in the mixture.

Davies and Jones (69) in 1932 compared the effectiveness of derris wash (1 lb. derris powder, 1/4 lb. soft soap, 1 imp. gal. water) and cube wash for the control of ox warbles. In critical tests where a wash of cube-root powder was used at the strength of 1 pound of cube root per gallon a 100-percent kill was obtained. At 1/4 pound per gallon a few warbles remained alive. Dry derris powder gave a kill of 95.1 percent and the derris wash a kill of 100 percent.

Götze (122) in 1932 recommended suspensions of derris in soap solution as by far the most suitable means of treating warble fly larvae. One kg. of finely ground root of Derris malaccensis was steeped in 9 liters of cold water for 24 hours, with frequent shaking. Just before use, a solution of 250 gm. of soft soap in 1 liter of water was added. The mixture was not filtered. Decomposition took place after about a week. This mixture was rubbed thoroughly on the animal's back and repeated after 2 or 3 days. Each application required about 250 cc. of the solution. No harmful effects on the animals were noted. The control was said to be 95 percent.

The Department of Agriculture of the Irish Free State (147) in 1932 described experiments made in Ireland in 1930 and 1931 with Polvo (ordinary powdered derris root) for the control of ox warbles. It was recommended in preference to Katakilla and Cooper's Warble Fly Powder, but soft soap must be used along with it. Tests are also described with Katakilla, Paragrad, Cooper's Warble Fly Powder, Cooper's Cattle and Warble Wash, and Cooper's Warble Fly Ointment.

The Isle of Man Board of Agriculture (149) in 1932 reported on the control of the ox warble fly. Reference is made to the Worcestershire Experiments on the control of this insect. The best dressing was considered to be Polvo powder 1 pound, soft soap 1/2 pound, water 2 imperial gallons.

Kürschner (164) in 1931 reported the proceedings of the sixth meeting on warble fly control held at the German Ministry of Agriculture. It was stated that infestations occurred only in certain regions of Germany, that various larvicidal substances, including derris, were available, and that mechanical removal could also be resorted to.

The United States Department of Commerce, Bureau of Foreign and Domestic Commerce (298) in 1932 published information on warble fly extermination in Germany transmitted by the American commercial attaché in Berlin, as follows:

> A new method of combating warble fly was suggested at the last conference held in the Federal Ministry for Foodstuffs. A veterinary journal has now approved this new method which has proved highly efficient and which is considered to be easier to handle than the treatment with "Larfug" ointment, with grub sticks, and by various other methods. The new method consists of repeated washing with a solution of tuba and derris roots.
>
> The solution was prepared as follows: One thousand grams of derris powder was soaked in 9000 cc. of water for 24 hours during which time the water was stirred repeatedly. The water soon assumed a milky appearance. A solution of 250 gm. of soft soap in 1,000 cc. of water was added so that a total quantity of 10 liters of washing solution were obtained from one kilogram derris powder. The powder is retained in the solution, which has to be shaken up for use. The solution of derris and soap disintegrates after about 1 week so that supplies can be prepared only for this period. The treatment of cattle is very simple and requires only a few minutes. The infected parts of the back are rubbed with the hand while the solution is applied in small quantities. It is not necessary to remove the hair. The individual boils are freed from crusts and the boils are washed carefully. Animals that are only slightly afflicted will require 150-200 cc. of the solution, while more serious cases will require 300-400 cc. The washing is repeated after 2 or 3 days. On the average, approximately 500 cc. of solution will be required for each animal for 2 treatments, so that about 20 head of cattle can be treated with 1 kg. of derris powder, at a cost of about 20 pfennigs per head.
>
> This treatment turned out to be more efficient than that of any other chemical preparation tested for this purpose. Both young and old grubs were killed.

The destruction of old grubs could be ascertained beyond doubt by their soft condition after about 3 days. The appearance of fresh grubs was not noticed until about 4 weeks after the treatment. This effect was obtained only after a double treatment at an interval of 1 to 3 days and only when very finely ground derris roots were used, but more than 90 percent control was obtained with only one thorough treatment. The results obtained with solutions made from coarsely chopped root were not nearly so good.

The same Bureau (299) in 1932 stated that the Warble Fly Committee of the Leathersellers' Company (170, 171), London, reported that experiments with derris preparations had been conspicuously successful.

According to the Warble Fly Committee (170) in 1930, more than 10,000 cattle in Worcestershire, England, were treated with the Polvo wash. In 1932 the Leathersellers' Company (171) published information on tests carried out at various places in England, Ireland, and Scotland during 1931. Derris was tried in the following forms: Dry derris powder, derris-soap wash, Polvo, Katakilla, Cooper's Warble Wash, and Cooper's Warble Powder. In northern Ireland tests on 805 cattle showed that 99.5 percent of the warbles were killed by four applications of the derris-soap wash (1 lb. Polvo, 1/4 lb. soft soap, 1 imp. gal. water). In tests in Caernarvonshire dry derris powder killed 98 percent of the warbles.

Burton (46) in 1934, in a lecture on the warble fly, referred to the conclusion of the Leathersellers' Warble Fly Committee that a derris-soap wash, applied to the warble lumps with a fairly stiff brush was an economical, efficient, and practical way of killing the grubs in the animal's back.

Pettit (232) in 1932 described the method of applying Gusanol (a proprietary derris product) to cattle for the control of Hypoderma larvae.

Townsend (276) in 1932 gave directions for the use of derris powder against warbles as follows: Derris 1/2 pound; soft soap 1/4 pound, water 1 imperial gallon, applied by hand with a cloth or brush or with a squirt can. Its action is due to the mild poison it contains and to the fine particles stopping up the breathing holes of the grubs.

Baudet (18) in 1933 reviewed the results of tests by Götze with derris-soap wash and by Peter to control ox warbles. Peter did not obtain so good results from the use of Cooper's Warble Powder as English authors described.

Baudet and DeBoer (20) in 1933 reported on the control of ox warbles with a water extract of derris made by soaking 1 kg. of derris powder containing 2 percent of rotenone in 9 liters of water for 24

hours, after which 250 gm. of soft soap dissolved in 1 liter of water was added. The extract was prepared just prior to use. As a rule one application was sufficient, but a second made a few days later ensured the death of all the larvae. The mixture was well brushed onto the backs of the animals, 5 to 14 fluid ounces being required for each. An ointment of vaseline containing 2 percent of rotenone also gave excellent results, the hair around the warble having been cut before its application. Rotenone dissolved in the oil killed the larvae, but the resultant irritation makes it unsatisfactory in practice. Mixtures of rotenone with turpentine also caused irritation and were not so effective.

Götze (123) in 1933 reported on the value of a number of proprietary derris products for the control of ox warbles. Products tested were: Derrothan-emulsion, Ludwig Meyer's ôily preparations Nos. 2068 and 2069, and three rotenone or derris solutions sold by the Chemische Fabrik Marienfelde and designated India-sine-rotenone-Lösung, India-rotenone-Lösung, and India-gesamtextrakt-Lösung. Two applications of a product containing 8 percent of rotenone diluted 1:50 killed 96.4 percent of the warbles.

Gusanol, a proprietary derris ointment, was recommended for the control of ox warbles by the Illinois Agricultural Experiment Station (145) in 1933.

Peters (231) in 1933 reported on warble control in Germany. One kg. of fine derris powder was soaked in 9 liters of cold water for 24 hours. To this was added 2.5 kg. of soap in 1 liter of water. Two applications of this mixture killed all warbles in the backs of cattle.

Remien (237) in 1933 reported on the value of some proprietary derris products, including Derrothan-emulsion, India-rotenone-Lösung, India-gesamtextrakt-Lösung, and India-sine-rotenone-Lösung, for controlling Hypoderma larvae in the backs of cattle. All warbles on animals washed twice with an aqueous solution of 0.68 percent of rotenone and 2.5 percent of soap were killed.

Spoon (257) in 1933 reported that rotenone was of great value in the control of cattle grubs.

The United States Department of Agriculture, Bureau of Animal Industry (280) in 1933 recommended the use of derris against cattle grubs, stating that animals infested can be effectively and safely treated by the owner with small medicated rods inserted in the warble holes. This method appears to be the most effective, rapid, and safe so far devised for use by the cattle owner. Of a large number of formulas tested, the one that gave the best results was: Gum arabic 6 drams, glue 2 drams, tannic acid powder 2 drams, derris powder 1 ounce, and enough water to make a stiff paste. This paste is then rolled into the form of rods. When properly used, the rods are 100-percent effective in killing grubs. The ingredients are harmless to cattle, and the preparation is easily standardized. There appears to be little danger of spreading infection from one lesion or animal to another, a thing which often occurs when infected instruments are used.

An anonymous (4) writer in 1934 outlined plans for Ontario farmers to combat warbles in cattle with the derris-soap wash. In 1932 Stevenson on Barrie Island treated cattle having an average of 15 grubs per animal, and as a result of this treatment the average number of grubs per animal fell to three in 1933.

According to Bartels (14) a derris suitable for treating cattle grubs should contain at least 8 percent of rotenone. Good results were reported in 1934 by the use of Delicia-Dasselöl, a proprietary derris product.

Helmig (139) in 1934 reported the results of tests of the following proprietary derris products against ox warbles: Derrisol, Derris-Viehwaschpulver, Abdassol, Rufus Nos. 99, 114, 214, 228, 314, Lianol, and Garapatox-Fautan. Abdassol and Derrisol in 10-percent solution gave the best control, namely, 93 to 94 percent.

Baudet (19) in 1934 reviewed the work of several workers on the control of cattle grubs. Peters found that excellent control was obtained by the use of a derris suspension prepared by soaking 1 kg. of finely ground derris in 9 liters of water for 24 hours and then adding 250 gm. of green soap in 1 liter of water. He recommended one application before the animals are placed in pasture in the spring and a second application in May or June. The first application killed 97.6 percent of the larvae. Remien carried out experiments with several proprietary rotenone-containing preparations. One, containing all the derris constituents except rotenone, killed 31 percent of the larvae; 96 to 97-percent control was obtained when the 10 percent of the nonrotenone derris constituents were present. Derris suspensions prepared the same as those used by Peters killed 98.6 to 100 percent of the larvae. A rotenone suspension described as a "sort of colloidal solution" was prepared by dissolving 3 parts of rotenone in 20 parts of pyridine, adding 80 parts of alcohol, and then adding this solution to 280 parts of a 2.5 -percent soap solution. The rotenone did not settle rapidly from this suspension when distilled water was used to prepare the solution. This preparation killed 92 percent of the larvae on cattle washed with it. Subcutaneous injection of derris extract in a calf infested with larvae was without effect. This was to be expected, as the larvae are not dependent on the body fluids of the host. Götze obtained satisfactory control of the cattle grub with a solution of rotenone in soybean oil and also with a suspension of derris in proprietary oils prepared by Schering-Kahlbaum.

Baudet and DeBoer (21, 22) in 1934 obtained good results against ox warbles with derris powder (8 percent rotenone) mixed with soapy water 1:30. Rotenone dissolved in acetone and mixed with soapy water also yielded good results. Care must be taken that all larvae come into contact with the medicament used.

A writer signing as G. B. O. (222) in 1934 gave the following formula for warble control: Derris 1 pound, soft soap 1 pound, in water 1 imperial gallon.

Vogel (303) in 1934 reported that three derris extracts diluted 1:50 caused 90.8, 56.8, and 58.1 percent, respectively, of the warbles in the backs of cattle to heal. An extract diluted to contain 0.24 percent of rotenone caused 95.6 percent to heal and gave the best control of any material tested. Derrilavol, Derri-Tox, Derro-emulsion, Deumos, Dasselfliegenbekampfungsmittel, Panderran I and II, and Cooper's Warble Fly Powder were other derris products tested.

Zunker (331) in 1934 reported tests of proprietary derris products against Hypoderma larvae in the backs of cattle. Abdassol (also called D8) killed 63 to 95 percent; D7, 67 percent; D9, 90 percent; and Polvo, plus soap, 74 percent.

An anonymous (5) Dutch writer in 1935, recorded results against cattle grubs with two lots of derris, one containing 2 percent of rotenone and 8 percent of ether extract, used at the rate of 1 kg. to 9 liters of water, plus 250 gm. of green soap in 1 liter of water; the other containing 8 percent of rotenone and 21 percent of ether extract used at the rate of 1 kg. to 40 liters of water. Soap is not necessary; neither is soaking the powder in water. Satisfactory control of the cattle grub was also obtained with rotenone, 10 gm. in 250 cc. of acetone added to 4 liters of water.

DeBussy et al. (49) in 1935 wrote that derris was an established remedy for the control of warble flies.

Spoon (258, 259) in 1935 wrote that for use against Hypoderma, derris powder containing 2 percent of rotenone and 8 percent of ether extract was agitated in 10 parts of water for 24 hours, and to the mixture was added 0.25 part of green soap in 1 part of water. The suspension was rubbed into the back of the animal with a small brush, an average 250 cc. being used for each animal. When derris powder containing 8 percent of rotenone and 21 percent of ether extract was used, 1 part of derris was suspended in 40 parts of water. The addition of soap was found to be unnecessary. Satisfactory control was also obtained by suspending 1 part of derris (8 percent rotenone, 21 percent ether extract) in 10 parts of water, and applying the suspension immediately. It was not known whether lower concentrations would be effective without a longer period of extraction. Later that year Spoon reported on the use of derris powder in Holland. In the Wieringermeer district, 65 kg. of derris powder containing 8 percent of rotenone was used for the treatment of 4,000 yearlings, 2,000 of which received a second application. On the island of Ameland, 20 kg. of derris (same sample) was used for the treatment of 1,635 cattle. The cost of derris powder for a single treatment amounted to about 2 cents in American currency. The method of application was as follows: 400 gm. of derris powder was suspended in

9 liters of water, and the suspension was frequently agitated during a 24-hour period. To this suspension was added 1 liter of green-soap solution containing 250 gm. of green soap. This suspension was shaken just before use and was brushed into the animal's hide. The results were satisfactory. The addition of the green-soap solution was considered unnecessary. Satisfactory results were also obtained by brushing the cattle with a liquid containing 10 gm. of rotenone dissolved in 250 cc. of acetone, added to 4 liters of water, and by application of a salve containing 8 percent of rotenone in vaseline.

Stefanski and Obitz (261) in 1935 reported that in Poland a wash of powdered derris root and soft soap, applied at the rate of 4 gm. of powder, 2 gm. of soap, and 40 gm. of water per animal, and one made with a powder in which derris was incorporated with soap, were tested and each killed an average of 90 percent of the larvae. As the young larvae are easier to kill, it is important to apply the treatment in the first half of April, before the animals are put out to pasture, repeating it at the end of May.

Bartels (15, 16) in 1936 called attention to the finding of mummified Hypoderma larvae in the backs of cattle that had been treated with derris preparations such as Derrilavol, Derrisol, and Derriphen. Later in the year he recommended standardized derris preparations for the control of larvae in the backs of cattle. Derris root should contain at least 8 percent of rotenone and 25 percent of total extractives. Mention was made of the proprietary derris products Derrilavol, Derrisol Derrophen, and Panderran.

Gibson and Twinn (109) in 1936 reported that losses from all causes attributable to warble flies in Canada had been estimated at from 7 to 14 million dollars annually. The standard treatment was to apply derris wash: Standardized derris powder 1 pound, soft soap 1/4 pound, and water 1 imperial gallon.

The Ministry of Agriculture of Great Britain (125) in 1936 called attention to its Warble Fly order of that year, requiring that infested cattle be treated by mechanical means to remove the maggots, or else treated with a wash containing either 1.5 ounces of derris resins or 0.5 ounce of rotenone plus 4 ounces of soap per gallon. Treatment must begin between March 15 and 22, or as soon as the maggots appear under the skin, and must be repeated at intervals of not less than 27 or more than 32 days, as long as they continue to appear. The dressing must be applied so that it shall come in contact with the larvae through the breathing holes made by them in the skin. The Governments of Northern Ireland and the Irish Free State had adopted similar measures in their countries.

Handa (135) in 1936 reviewed work on the warble fly in India and referred to the use in England of the derris-soap wash.

Hoenig (140) in 1936 tested four derris preparations for warble control on cattle. One washing with a 4-percent solution of Pan-derran-Merck killed 83 percent of the larvae. A single washing with a 5-percent Abdassol solution resulted in the death of 88.8 percent, whereas one washing with a 10-percent solution produced 95.6 percent of healing. Abdassol was the most satisfactory agent because of its ease of application (foaming readily), its cheapness, great effectiveness, and complete harmlessness to the animals. A single washing with a 10-percent Derrisol-Bengen solution gave a kill of 91.5 percent. One washing with a 4-percent Derrilavol solution resulted in a 76.8 percent kill of the larvae, which the author did not consider sufficiently good.

The Department of Agriculture of the Irish Free State (148) in 1936 reported experiments made in Ireland for the control of Hypoderma larvae with Polvo and Paragrad. Polvo requires the addition of a spreader for successful application. The spreader (soft soap) is dissolved in hot water and mixed with the Polvo to form a paste, which is then reduced to the required strength by the addition of water. Paragrad has a spreader incorporated in it, and all that is necessary is to mix the powder with water to form a paste and reduce it to the required strength by the addition of water. The preparation is then ready for use. The dressings were used at the following strengths: Polvo 1/2 pound, soft soap 1/4 pound, water 1 imperial gallon; Paragrad 1/2 pound, water 1 imperial gallon. The dates of the first application varied at the different centers, depending on the maturity of the grubs but, generally speaking, the first dressing was applied about the last week of March and repeated at intervals of a month. Three applications, and in some cases only two, were generally sufficient for the complete destruction of all grubs. The number of animals treated was 965. The total number of grubs that appeared during the tests was 13,891, an average of 14.4 per animal. On the cattle treated with Polvo a total of 6,805 warbles developed, and 6,701 or 98 percent were killed. On the cattle dressed with Paragrad 7,086 warbles appeared and 6,868, or 97 percent, were killed. From the above results, there is apparently little choice between Polvo and Paragrad. Most of the instructors in these trials favored Paragrad because it is easier to prepare, needing only the addition of cold water, whereas with Polvo both soft soap and hot water are required.

The Koloniaal Instituut of Amsterdam (162) in 1936 reported that, in general, the various stages of Diptera are but little sensitive to derris. The larvae of the warble fly is a favorable exception. Finely ground derris root seems to be a powerful control measure against this pest and is not injurious to domestic animals or man.

According to Van der Laan (166) in 1936, the larvae were sensitive to derris.

Maheux (194) in 1936 published directions for the treatment of warbly cattle in Quebec with proprietary rotenone preparations.

Pedretti (229) in 1936 reported on the control of Hypoderma larvae with derris preparations. Tests were made with Abdassol, Derrilavol, Derrisol, Derrophen, and Laurus-Desselpulver.

Bartels (17) in 1937 reported that derris preparations gave a high percentage of control of Hypoderma larvae.

Hardtmann(137) in 1937 stated that for combating warble fly larvae in the skins of cattle, oil sprays containing 0.05 percent of rotenone were employed.

The Louisiana Agricultural Experiment Station (184) in 1937 reported that derris powder dusted into the warble holes killed a high percentage of grubs.

Natvig (210) in 1937 reviewed work on ox warble flies in Norway and stated that various washes, including derris, were used.

The Runderhorzel-Bestrijdings-Commissie (245) of Holland, in 1937 recommended aqueous suspensions of derris root for control of cattle grubs.

An anonymous (7) writer in 1938 reported on the warble fly pest in England. The percentage of hides with open warbles handled by the Hide Improvement Society during the first 9 months of 1938 was slightly greater than in 1937, but less than in 1936. Derris sales in 1937 and 1938 were much less than in 1936. The Ministry of Agriculture held that rigid enforcement of the Warble Fly (Dressing of Cattle) Order would only antagonize farmers generally and defeat its own object. "Enforcement should be tightened up gradually, but at the present the Order should be the background for an educational and propaganda campaign, bringing home to farmers their obligations under the Order and the advantage to themselves of observing its provisions. The number of prosecutions reported to the Ministry during 1938 was 94, against 51 in 1937, and 8 in 1936.

The United States Department of Commerce, Bureau of Foreign and Domestic Commerce (301) in 1940 called attention to an order of the British Ministry of Agriculture making the use of derris preparations for cattle dressing obligatory. This is a modification of the "Warble Fly (Dressing of Cattle) Order of 1936." The original order permitted the removal of maggots from the skins of affected cattle by mechanical means. This alternative was later withdrawn and it was required that all visibly infested animals be treated during the current season by the application at monthly intervals of a derris dressing prepared according to specifications in the order.

Edwards (79) in 1938, in a popular account of rotenone-containing insecticides, stated that they were effective against warbles on cattle.

Hearle (138) in 1938 published directions for preparing derris wash (derris powder 1 lb., soft soap 1/4 lb, water 1 imp. gal.) for use against cattle grubs.

Thomssen and Doner (274) in 1938 reviewed published information on fly control for livestock and mentioned rotenone for killing Hypoderma larvae.

Dinulesco andFoisoreano (75) in 1939 reported that in the laboratory extracted grubs placed in contact with derris extract at the temperature of the host were killed after 5-1/2 hours.

M. P. Jones (158) in 1939 recommended derris or cube for the control of cattle grubs.

L. G. Smith (256) in 1939 called attention to the control demonstration of cattle grubs carried out on a herd of 150 head of beef cattle in Garfield County, Wash. Excellent results were obtained from 4 treatments beginning in December 1938 and applied every 20 days. The wash consisted of 1 pound of 5 percent cube root and 2 ounces of soap in 1 gallon of water, applied to the backs of the animals at the rate of 8 ounces per animal, and thoroughly scrubbed in with a brush.

Wells (310) in 1939 reported the results of a series of tests on the use of derris and cube washes on the backs of cattle for control of cattle grubs in Colorado and Iowa. By using derris and cube washes (16, 12, 6, and 4 oz. plus 4 oz. soap per gallon of warm water) on the backs of cattle, it was found that 1 quart of the solution was sufficient to treat only 3 animals with such winter coats as are found in Colorado and Iowa. After distributing the powdery wash over the back it was necessary to devote 2 man-minutes of rubbing the wash into the hair with the hands. Rubbing with a brush was less efficient. With an equal amount of rubbing, 12 ounces of the powder per gallon of wash was as efficient as 16 ounces. Eight ounces of powder per gallon with the 2 man-minutes of hand rubbing was survived by approximately 9 percent of the grubs, whereas with 16 ounces per gallon the best result was a survival of 3.15 percent. The powders contained rotenone and extractives as follows: Derris 6.2 percent of rotenone and 15.5 percent of total extractives, cube 4.7 percent of rotenone and 21.1 percent of total extractives. In all, 186 cattle were used, each being handled twice, first for application of the wash and second for extraction of the grubs, which totaled 4,708. The cube powder gave better results than the derris.

The Idaho University, College of Agriculture (144) in 1940 recommended ground derris or cube root (rotenone 3 to 5 percent) 12 ounces, and neutral soap 2 ounces per gallon of water for control of cattle grubs. The material should be mixed just prior to each treatment and applied with a stiff brush with sufficient force to enter

the holes cut in the skin by the grubs. Treatment should begin about December 20-25 and should be repeated at 25-30-day intervals until no more grubs appear on the backs of the animals.

Otitidae

Euxesta stigmatias Loew

B. A. App in 1936, in a typewritten report to the Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, stated that a derris-talc dust containing 1 percent of rotenone showed a control of 3.9 percent of maggots, as compared with 19 percent by the lead arsenate dust.

Psilidae

Psila rosae (F.), the carrot rust fly

Smith and Wadsworth (255) in 1921 tested insecticides against the carrot rust fly. Four applications of a powder composed of soot and derris at the rate of 1 ounce of derris plus 2 ounces of soot per square yard resulted in 95 percent of clean carrots. The control plot yielded only 20 percent of carrots free from infestation. This derris mixture gave the best control of any of the materials tried.

K. M. Smith (254) in 1925 reported that tests were made with various insecticides. A mixture of 1 ounce of derris with 2 ounces of soot per square yard did not give results promising enough to justify further trials with it.

Kelsall et al. (159) in 1926 reported that derris in either dust or liquid form gave a considerable measure of control, the material being applied to the soil surface about the time egg laying was in progress. The control was apparently accompanied by plant stimulation also.

The Massachusetts Agricultural Experiment Station (197) in 1929 stated that derris products had given very encouraging results against the first generation in 1927 and 1928 but were ineffective against the second generation.

Glasgow (114) and Glasgow and Gaines (116) in 1929 reported that five applications of derris dust at weekly intervals were ineffective in combating immature stages in soil. Mercurous chloride was 100 percent effective.

Whitcomb (316) in 1929 reported promising results with derris compounds for control in Massachusetts. In the laboratory all flies confined with potted carrots dusted with powdered derris root died

in less than 24 hours. The insecticide was as effective 3 days after it was applied as when fresh, and when diluted 1:4 and 1:2 with gypsum killed the flies as readily as in pure-dust form. In the field the pure powdered derris root gave 87-percent protection after treatments with a hand duster on June 16 and 23 and July 2. The untreated plot suffered 78-percent injury. Derris-gypsum dust, Derrisol spray, sodium fluosilicate spray, and corrosive sublimate solution gave 70 percent or more protection under the same conditions. Similar treatments on August 21 and 29, applied under less favorable conditions, were not so effective against the late brood of maggots.

The Massachusetts Agricultural Experiment Station (198) in 1931 stated that in laboratory tests, derris dust, both pure and diluted 1:2 with gypsum, was very effective in killing adults and prevented ovipositon, whereas eight other materials were much less effective.

Gorham (121) in 1934 reported on control in Quebec. Derris powder in suspension in water and Derrisol in solution were among the most effective insecticides. Derris dust gave results equal to the liquid preparations, but all other dusts tried were somewhat less effective than liquids. The critical time for insecticidal action is just after the larva emerges and while it is still close to the soil surface. The average results obtained during the last four years with the four most efficient materials are shown in the following table:

Material	Average injury by larvae	
	Spring	Autumn
	Percent	Percent
Mercury bichloride, 15 pounds per acre, 18 plots	0.64	12.65
Derris, 15 pounds per acre, 20 plots	2.20	31.05
Derrisol, 5 pounds per acre, 16 plots	4.36	28.71
Sodium silicofluoride, 400 pounds per acre, 12 plots	4.04	25.52
Checks, 48 plots	34.03	51.12

The Massachusetts Agricultural Experiment Station (200) in 1938 reported that four applications made on June 5, 12, 19, and 26, of cube-clay dust to carrots from seed sown May 4 gave complete protection and can be recommended.

Whitcomb (317) in 1938 reviewed laboratory tests of insecticides. In 1929 eggs were placed on moist blotting paper in petri dishes and

carefully but thoroughly sprayed or dusted. The materials used were corrosive sublimate solution 1:1,000, Derrisol spray 1:250, bordeaux-oil emulsion (1-percent oil), 4-percent calomel-lime dust, and undiluted ground derris root (5 percent rotenone). No larvae hatched from eggs exposed to any of these treatments, but about 20 percent hatched from the untreated eggs. During 1928, 1929, and 1930 about 300 newly emerged flies were confined in groups of 10 in lantern-globe cages over potted carrots that had been sprayed or dusted with various insecticides. Where dusts were used, the flies were confined with the treated plants immediately after application, except in special experiments; but the liquid sprays were allowed to dry on the plants before the flies were caged with them. Derris killed the flies with unusual speed and consistency. Applied as a dust, derris mixtures killed all flies within 2 days. Another series of tests indicated that undiluted derris dust killed all the flies in 24 hours when they were confined with the plants 4 days after the dust was applied, but it was only partially effective 5 or 6 days after application. Derris-gypsum dusts containing 75 and 50 percent of derris killed all the flies within 3 days after application, but a dust containing 33 percent of derris killed only 70 percent of the flies exposed to it immediately. In field experiments derris and cube have been the most consistently effective materials, especially to control the first-generation flies on early carrots. Good results with derris were also obtained by Gorham (reported by correspondence) in New Brunswick, Canada.

In the first work with derris, the undiluted derris root was superior to any mixture of it with gypsum. In fact, the greatest commercial damage by the flies where this treatment was used was 13.2 percent in 1928, which represented a gain of 64.4 percent over the check; and the average loss in 3 years was only 7.73 percent. However, ground derris root costs at least 40 cents a pound and, undiluted, is much too expensive for commercial use on carrots. Since 1933, derris and cube powders have been improved by careful grinding and handling. In 1937 four applications of a cube-clay dust containing 0.6 percent of rotenone gave complete protection from a 14-percent infestation in an adjacent check; and in 1932 and 1933 a similar commercial dust containing 0.55 percent of rotenone permitted an average damage of only 3.5 percent, which represented the greatest gain from any treatment with a contact insecticide against the second generation. This dust is now readily available for about 13 cents a pound, and used at the rate of 50 to 75 pounds per acre it would cost from $6.50 to $10 for each application. This expense has not been justified in the last few years; but with a heavier infestation and a yield of 500 bushels or more per acre, it might be practical on early carrots. On small plantings and home gardens it can be recommended. Sprays containing rotenone have been effective but in most cases are more difficult to apply. Pyrethrum as a dust or spray was less effective than derris or cube.

Scatophagidae

Scatophaga stercoraria L.

According to De Bussy et al. (48) the full-grown flies are much more

susceptible than houseflies. Dusting with a derris mixture containing 0.5 percent of rotenone and 1.2 percent of ether extract killed all the flies within 24 hours.

Syrphidae

Allograpta obliqua Say

Little (182) reported in 1931 that the larvae were not affected by the powdered root of Tephrosia virginiana in laboratory tests.

Lampetia equestris F., the narcissus bulb fly

According to a letter from Etablissements Rotenia to R. C. Roark in 1938, (Merodon) Lampetia equestris on tulips was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum.

Schopp and Eide (247) in 1939 reported the results of experiments with insecticides at Sumner, Wash., in 1938. Better than 50 percent control was obtained with a cube-root dust mixture containing 0.5 percent of rotenone. This dust mixture was applied at the base of the narcissus plant, where the bulb flies ordinarily oviposit. The first application of the insecticides were made on May 6, coinciding with the time of emergence of the first adults, and, since heavy showers occurred soon after the first applications, they were repeated on May 23.

Merodon geniculatus Strobl.

Delassus (70) in 1931 reported that in laboratory tests steeping bulbs of ornamentals (Amaryllidaceae) in a decoction of derris was ineffective against larvae of this syrphid.

Syrphus americanus Wied.

Little (182) in 1931 reported that the larvae were not affected by the powdered root of Tephrosia virginiana.

Syrphus spp.

Wilbaux (321) in 1934 tested extracts of 22-year-old leaves of Tephrosia vogelii and reported that as a contact insecticide the leaves are about as toxic as nicotine. Larvae of Syrphus were resistant to sprays containing 1 part to 200 of the dry vegetable matter.

Kelsall et al. (159) in 1926 reported that derris, 1.5 pounds per 100 gallons of water, with soap, was used against aphids on a cutleaf birch. Larvae of syrphid flies were killed and dropped in a few hours, but the aphids did not appear to be affected during the first 12 hours. Two days later the tree was found to be completely free from aphids.

Kuijper (163) in 1929 reported that syrphid flies were resistant to a spray containing an aqueous extract of derris root.

The New Jersey Agricultural Experiment Station (212) in 1938 stated that in studies on pea aphid control derris dusts destroyed a large number of syrphid fly larvae, which predator enemies of the pea aphid are.

Tabanidae

The United States Department of Commerce, Bureau of Foreign and Domestic Commerce (300) in 1938 published information received from the American Consulate General at Frankfort-on-Main, Germany, that rotenone-containing preparations had been found to be most effective in Germany for combating the horsefly pest.

Tipulidae

Tipula spp.

Thompson (273) in 1928 tried derris in poison bait against leatherjackets in South Wales and found that, although it did not give as good results as the paris green bait (1 lb. paris green, 20 lb. bran, moistened with 1/2 imp. gal. water), it is obviously of definite insecticidal value when used in this way. On the derris-treated plot numerous earthworms, and also some slugs, were found lying dead on the surface. Derris powder clearly does not render the bait distasteful to the pests named, as appeared to be the case with sodium fluosilicate. The derris bait was composed of 10 pounds of bran and half a pound of derris powder distributed over half an acre of oats. Thompson concluded that derris powder gives moderately good results.

An anonymous (6) writer in 1937 stated that derris was ineffective against craneflies.

Trypetidae

Ceratitis capitata (Wied), the Mediterranean fruitfly

Miller and McBride (205) in 1931 recorded tests of various materials used in a solution of 50 pounds of sugar, 10 gallons of sirup, and 190 gallons of water, against the Mediterranean fruitfly in Florida. The sirup was a very cheap grade of black-strap molasses, and the sugar was a coarse brown grade. The addition of 1 pint of a proprietary product called "Derris Emulsion 5 percent derris resin" to 200 gallons of this sugar solution caused a mortality of 80 percent of the flies in 9 days, as compared with a 12-percent mortality in the check test.

Bourdier and Foury (36) in 1936 reported that molasses plus derris (14 kg. of molasses, 1 liter of commercial insecticide containing 50 gm. of rotenone, and 100 liters of water) killed 50 percent in 7 days. Arsenicals and fluorine compounds gave much better results.

Rothe (244) in 1937, in discussing means of combating this species

in Germany, referred to a special contact poison that apparently contained derris and was used in admixture with summer oil spray.

Ceratitis (Pterandrus) rosa (Karsch)

Ripley and Hepburn (240) in 1931 reported tests to determine the comparative toxicity to the Natal fruitfly of fluorine compounds, lead arsenate, copper carbonate, Derrisol, and Pulvex. The tests were made by suspending a cylindrical roll of absorbent cotton wool, 8 inches long and 1-1/2 inches in diameter, from the center of a cage 1 foot square and containing 50 flies, 25 of each sex. The cotton had been soaked in a solution containing 62.5 gm. of white sugar per liter plus the poison being tested. Derrisol diluted 1 part to 500 parts of sweetened water acted neither as an olfactory nor a gustatory repellent and showed a high toxicity considerably greater than that of lead arsenate at 0.23 percent. It appeared to be somewhat too volatile, however, always failing to kill 10 percent or more of the flies, these having fed presumably after the rotenone had largely volatilized. Pulvex was far less toxic than Derrisol, dilutions of 1 part to 300 of sweetened water ranking considerably below Mally bait in toxicity.

Dacus cucurbitae (Coq.), the melon fly

The Federated Malay States Department of Agriculture (84) in 1937 reported on tests made in 1936. Spraying and immersion tests with adults as subjects, were carried out with aqueous solutions of Derris elliptica, rotenone, lime precipitate of derris, deguelin, rotenone-free resin solution, and solutions of the new solid and liquid derivatives of derris. Rotenone and deguelin were dissolved in acetone to which a small amount of Agral was added and the new solid was tested in solution in ethylene glycol monoethyl ether. In some tests this species was anaesthetized with ether before being sprayed.

Dacus (Chaetodacus) sp.

The adults were used by the Federated Malay States Department of Agriculture (83) in 1936 to test the toxic value of derris extracts.

Epochra canadensis Loew, the currant fruitfly

Wood (325) in 1912, in describing the use of derris as an insecticide in Malaya, stated that its use against the gooseberry maggot in English orchards would be well worth a trial.

Hanson and Webster (136) in 1938 recommended derris dust (0.5 percent rotenone) or spray (0.02 percent rotenone) for the control of the yellow currant fly.

Platyparea sp.

According to a letter from Etablissements Rotenia in 1938 to R. C. Roark, this pest on asparagus was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum.

Rhagoletis cerasi (L.)

See Jancke (150) under Pegomya hyoscyami Panz., on page 5.

Sprengel (260) in 1932 reported tests to control the cherry fruitfly in Germany. The proprietary derris products Polvo and Polvosol have been used as contact poisons in combating this insect. A dosage of 1/4 kg. of Polvo per tree was sufficient, whereas 1/2 kg. of pyrethrum was needed .

According to Deutscher Pflanzenschutzdienst (72) in 1933, when cherries are so ripe as to be susceptible to damage by sodium fluoride sprays, it is recommended that the entirely harmless derris be used, even though it is considerably more expensive.

Jancke and Böhmel (151) in 1933 reported tests made in Germany for the control of the cherry fly, A derris extract made from derris powder and acetone in the ratio of 1:2 was tested. A 100-percent kill was obtained with a 1:250 dilution in 4-percent of molasses and with a 1:500 dilution in a 2-percent sugar solution. The 1:500 dilution caused 55-, 70-, and 90-percent mortality, according to whether it was made with 1-percent glycerin, 4-percent molasses, or a combtination of the two. In comparison, a 1:500 mixture of pyrethrum with 4-percent molasses caused only 15 percent mortality. The acetone extract of derris is said to be very stable, and can be conveniently diluted with water.

Lang (167) in 1933 reported that the derris-containing proprietary insecticidal materials Polvo and Polvosol were applied four times within 3 weeks to young cherry trees for the control of the cherry fruitfly, but failed to give favorable results. There was some sound fruit, not exceeding one-third of the crop, from the treated trees, whereas every fruit from the untreated check trees was infested.

Stellwaag (262, 263) in 1933 reported a review by the Biologische Reichsanstalt of experiments relating to the control of the cherry fruitfly. Derris was tried in dust form, but because of the unsatisfactory conditions of many of the experiments no definite statement was made as to the results with this or any of the other materials used. In the same year Stellwaag also mentioned the fact that derris had been used as a dust in the control of the cherry fruitfly.

Wiesmann (320) in 1934 reported that Priox, Polvo (contains rotenone), and Herkosol were applied as dusts against newly emerged flies, but rain

prevented their being effective. Dry dust gave good results in the laboratory.

According to a letter from Etablissements Rotenia in 1938, to R. C. Roark, this pest on cherry trees was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum.

Rhagoletis cingulata (Loew), the cherry fruitfly; the cherry maggot

The New York Agricultural Experiment Station (214) in 1935 stated that derris plus an adhesive, such as gum arabic, applied as a spray reduced the number of cherry fruitflies appreciably.

Glasgow (115) in 1935 reported trials of substitutes for lead arsenate in control.

Three applications of derris powder (4 percent rotenone), when applied at a rate of 2 pounds to 100 gallons, reduced the fly infestation in one large sour-cherry orchard from approximately 30 percent in 1933 to less than 1 percent in 1934.

The New York State Agricultural Experiment Station (215) in 1937 reported that derris was being tested for control of the cherry maggot. The same station (217) in 1939 reported that tests on the use of rotenone sprays indicated that they are efficient substitutes for arsenicals on cherries to be sold as fresh fruit.

Hamilton and Pearce (134) in 1938 reported that preliminary experiments were carried out in New York in 1937 on the relation between programs for spraying with arsenicals and the residue on cherries at harvest time. Sprays of cube root (5.3 percent rotenone), flotation-sulfur paste, and soybean flour (2.5, 6.0, and 0.5 pounds per 100 gallons of spray), applied on June 5, 15, and 24 following a shuck-fall spray of lead arsenate (1 lb.), were tested on trees that had a 15-percent infestation by Rhagoletis cingulata and R. fausta O. S. during the previous season. Of over 10,000 cherries from 2 trees, only 0.35 percent were injured by Rhagoletis, but the lightness of infestation during the preceding year precludes definite conclusions.

The New York County Agents' Training School (213) held at Ithaca on December 19, 1938, heard reports that cherry fruitfly control tests conducted in plantings known to have been infested in 1937 gave the following results in 1938:

Spray material	Applications	Wormy fruit
	Number	Percent
Cube root 2 lb., soybean flour 1 lb. in 100 gal. of water	3	1.38
Do.	4	1.13
Phenothiazine 2 lb. in 100 gal. of water	2	4.56
Do.	4	.31
Light arsenicals following the grower's shuck spray	2	3.21

Hamilton (133) in 1940 reported that in field tests both cube root and phenothiazine reduced heavy populations of fruitflies (Rhagoletis cingulata and R. fausta) satisfactorily when at least three applications were made at the rate of 2 pounds per 100 gallons of spray. In one test a 15-percent-phenothiazine dust appeared to be nearly as effective as these sprays. Basic zinc arsenate only partially controlled cherry fruitflies when two light applications were made. Cube containing 4.4, 4.7, or 5.3 percent of rotenone was used at the rate of 2 or 2-1/2 pounds per 100 gallons. Soybean flour (1/2 lb.) or a commercial spreader (1 pt.) was used in most tests, also flotation sulfur paste (6 lb.) as a fungicide.

Rhagoletis fausta O. S., the black cherry fruitfly

See Hamilton and Pearce (134) and Hamilton (133) under Rhagoletis cingulata, on pp.77and 78, respectively.

Rhagoletis pomonella (Walsh), the apple maggot; the blueberry maggot

The Maine Agricultural Experiment Station (195) in 1935 reported that a pyrethrum-derris insecticide was tested for control of the apple fruitfly, being applied at the rate of 1:400 in the fourth cover spray. It is not feasible to draw conclusions from this preliminary test. Experiments with pyrethrum and derris will be continued.

Garman (91, 92) in 1936 reported that his first field experiment with derris was conducted that year and gave unfavorable results, but more work was needed to establish whether derris has enough action in the field to be considered. In 1936 he reported that in laboratory tests derris showed considerable toxicity to apple maggot flies; in field tests it was much inferior to either cryolite or lead arsenate but trees sprayed with it showed considerable improvement over unsprayed trees. A summary of laboratory control experiments to kill adult flies of the apple maggot is given in the following table:

Material and Solution	Tests	Flies	Egg punctures	Average punctures per fly
	Number	Number	Number	Number
Lead arsenate 2 gm./100 cc.	5	101	0	0.0
Natural cryolite 2 gm./100 cc.	6	112	1	.008
Derris (ground root) 2 gm./100 cc. with skim-milk powder	5	118	8	.06
Phenothiazine 2 gm./100 cc. with skim-milk powder	2	45	6	.13
Checks (no spray)	8	170	530	3.11

Procedure: Materials were diluted as indicated and sprayed uniformly on green, immature apples, which were then hung in the cages. Food was supplied but the only water provided was sprinkled daily on the apples. All tests were run for 20 days, after which they were discontinued and the apples were examined with a binocular for egg punctures. The temperature ranged from 75° to 78° F. and the relative humidity was about 60 percent. Flies were introduced shortly after emergence.

The results of field experiments to control the apple maggot at Experiment Station Farm, Mount Carmel, were as follows:

Materials	Infestation in fruits	Varieties
	Percent	
Lead arsenate-flotation sulfur	4.9	Hurlburt
Lead arsenate-lime	11.8	Greening
Cryolite-flotation sulfur	8.2	Mother, Stark
Cryolite-talc	11.1	Greening
Derris spray	28.1	Greening
Check (no maggot spray)	71.9	Greening

Sprays of derris 4 pounds, skim-milk powder 1 pound, bentonite 2 pounds, to 100 gallons of water were applied on June 27, July 10, and July 25; and sprays of derris 4 pounds, skim-milk powder 2 pounds, and water 100 gallons were applied on August 14. The derris powder contained 4 percent of rotenone.

Beckwith and Doehlert (24) in 1937 reported on the control of this species in cultivated blueberry fields with two nonpoisonous insecticides,

derris (.5 percent rotenone) and pyrethrum (0.9 percent pyrethrins). Flies were obtained in March and April from pupae in an incubator and were dusted with definite quantities of insecticide in a cage of measured size, in an attempt to determine which was the more effective dust and to approximate the lethal dose needed in the field. The temperature ranged from 65° to 70° F. Pyrethrum used at the rate of 90 mg. per cage (1/3 cu. ft.) killed the flies in 20 hours. Derris at the rate of 30 mg. per cage (1/3 cu. ft.) killed the flies in 3-1/2 hours, and in tests with smaller quantities it was found that 5 mg. to a cage would incapacitate flies within 2 hours and they would die without regaining motive power. No smaller dosages were tried. Five mg. to 1/3 cubic foot would be equal to 4-1/3 pounds per acre, treating a space 3 feet high, or 8-2/3 pounds per acre for a space 6 feet high. The treatment finally recommended was 10 pounds per acre for small plants and 15 pounds per acre for larger ones. Commercial treatments were made on 225 acres representing plantings of 10 different growers. Some operators used a monoplane and others an autogiro. The dosage was limited to 10 to 15 pounds per acre. Two small cages, 4 by 10 by 2 inches, of folded-wire mosquito screening, were used to hold flies in the center of large bushes in fields that were being dusted by autogiro. Six flies were used in a cage, and all were dead within 2 hours after treatment. Adults of Rhagoletis pomonella can be killed in cultivated blueberry plantations by dusting, from an airplane or autogiro, with 10 to 15 pounds of derris dust (5 percent rotenone) to the acre. The time for treatments in New Jersey is approximately June 27 to 30, and July 7 to 10.

The Connecticut State Agricultural Experiment Station (61) in 1937 reported that results of tests with various substitutes for lead arsenate in orchard sprays indicated that the best control of the apple maggot was obtained on the trees in the cryolite-derris plot sprayed with phenothiazine. Continued work with these materials appears to be desirable.

Garman (93) in 1937 reported that in general, the results obtained that year indicated that derris is a very good insecticide for killing apple maggot flies and that it kills much more rapidly than lead arsenate. This rapid kill was also reflected in a reduction in egg punctures amounting to 99 percent when the material was used as a spray at the same rate as lead arsenate. Small quantities of derris or allied material in the form of a dust containing 0.75 percent of rotenone, applied so as to cover the fruit surface in a very light layer, were also effective in killing the flies and preventing oviposition. Phenothiazine continued to show repellent action but in killing effect was not equal to either derris or lead arsenate. Wheat flour was used as a carrier in all tests except that with the rotenone dust, the sprays being applied at the rate of 3 gm. of poison and 3 gm. of flour in 800 cc. of water.

The New Jersey Agricultural Experiment Station (211) in 1937 reported that tests were made against this fruitfly infesting blueberries. Derris dust at the rate of 10 mg. or more killed the flies in 3 hours. Five mg. of derris disabled the flies in 7 hours so that they eventually died.

The Connecticut Agricultural Experiment Station (62) in 1938 reported that derris dusts were applied in July to control apple maggots. Regular sprays were discontinued after June 15 and three applications of a dust containing 0.5 percent of rotenone were made in July and August. At the station farm the results were better than for several years past. At West Woods, where a similar schedule was followed, the reduction in injury amounted to approximately 38 percent.

Garman (94) in 1938 reported that a dust containing 0.5 percent of rotenone applied with a power duster, seemed to have considerable toxicity for the apple maggot fly. In laboratory tests materials that proved to be effective when used as dusts were ineffective after being wet down and applied as a spray, even though considerable amounts were used in the spray. Apples heavily dusted were left for a few days in a greenhouse exposed to moisture and light. In these tests freshly applied dusts showed much greater effectiveness than similar dusts that had been exposed in a greenhouse for 5 days.

Garman and Townsend (97) in 1938 reported further studies on apple maggot control. In both laboratory and field tests a 0.5-percent-rotenone dust, with clay as a carrier, was shown to be more effective than lead arsenate in killing the flies. Exposure to light under greenhouse conditions destroyed the insecticidal action of rotenone dust completely in 5 days. Using the dust as a spray also destroyed its efficiency.

The New Jersey Agricultural Experiment Station (212) in 1938 stated that cage tests of insecticidal dusts against the adult fly were continued in that year with a total of 621 individuals in 34 lots. It was found that, in equal amounts, powdered barbasco and derris were equally toxic, each resulting in a practically complete kill where 2.5 mg. of 4-percent material was used in cages of 1/3-cubic-foot capacity. The same quantity of 6.7-percent timbo produced only a 50-percent kill. The substation's recommendation of 2 applications of 10 pounds of powdered derris per acre spread by aircraft on June 27-30 and July 7-10 was continued.

The New York Agricultural Experiment Station (216) in 1938 reported on insecticides, including phenothiazine, powdered cube root, and hydrated lime, which were tested under orchard conditions against the apple maggot in 1936. Six small orchards were treated, all the trees in each block receiving a single test material. Little or no control was obtained where hydrated lime alone was used, but the results from cube root and phenothiazine were sufficiently promising to warrant additional testing.

The New York County Agents' Training School (213) held at Ithaca in 1938 heard a report that further tests with rotenone in the form of powdered derris and cube root resulted in very poor control of the apple maggot. Apparently this material is "out" as an insecticide against this pest.

Garman (95) in 1939 reported that in field experiments in Connecticut, dusts containing 0.5 percent of rotenone, although successful in 1937, failed to equal that performance in 1938, partly because of the heavy July rainfall. High temperatures and humidities destroyed the rotenone rapidly, and flies were able to lay large numbers of eggs despite the 10-day interval of application, which theoretically should be ample considering the material and the nature of the insect. The addition of sulfur to the dust did not improve it. In 1939 Garman (96) reported that in the hottest part of July 1938, apples were dusted with rotenone dust and exposed to sunlight 1/2 day. By the end of that period, the killing power of the dust had disappeared, indicating a very rapid dissipation of its toxicity. About the only place for dusts of the kind mentioned (0.5 percent rotenone) is in late applications after the first of August, when flies need to be destroyed on early ripening varieties such as Gravenstein or Wealthy, and excessive residues should be avoided.

Lathrop (169) in 1939 reviewed the 10 years of warfare against the blueberry maggot. Under the heading "Further Investigation Needed", he states that studies of rotenone insecticides are of interest to the blueberry producers.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (295), in 1939 reported work done in 1938 by P. J. Chapman on the control of the apple maggot in the vicinity of Poughkeepsie, N. Y. Cube powder (4.4 percent rotenone and 22.9 percent total extractives) at the rate of 3 pounds per 100 gallons plus 1 pound of soybean flour was applied five times, but permitted an infestation ranging from 34.3 to 98.4 percent. Lead arsenate followed by zinc arsenate and two applications of phenothiazine gave the best control.

Garman and Townsend (98) in 1940 reported on the control of the apple maggot in Connecticut. A derris-pyrophyllite dust (0.5 percent rotenone) plus 4 percent of white lubricating oil applied as a dust was effective.

Although it appears too early to make specific recommendations concerning the use of rotenone insecticides for control of the apple maggot, it seems that such materials may have a place late in the season when it is desirable to avoid poisonous residues. They will doubtless be more successful in dry than in wet season, and it should be kept in mind that combinations so far prepared lose their potency, even in dry weather. They are not known to last more than 4 or 5 days on the trees. The extreme rapidity of killing action is in favor of rotenone dusts, as shown by cage tests, which frequently gave 100-percent knock-downs in 24 hours. Field observations indicate the same rapid destruction of flies in the orchard. Flies coming from unsprayed trees outside the orchard still remain a problem, but there is reason to believe that the chance of eliminating late comers with rotenone dusts is very good.

Unidentified species of Diptera

See Kelsall et al. (159) under Musca domestica, on p. 31.

Geoffroy (105) in 1895 described the following test made with nicouline (rotenone) extracted from the root of Lonchocarpus nicou: Flies were placed under a bell with a piece of sugar dried in an oven after being dipped into an alcoholic solution saturated with nicouline. The flies that came to the sugar did not take long to fall; they became lifeless, unable to fly, and manifested their vitality only by an intermittent trembling of feet and wings.

Daniels (65) in 1905 wrote that the effects of derris on dipterous larvae in cesspits filled with semisolid material are local only.

Gilmer (110) in 1923 reported that derris powder when blown into the air is not effective against flies.

The Handelsmuseum of the Koloniaal Instituut (161) of Amsterdam in 1930 stated that flies and fly larvae appeared to be immune to derris emulsion.

Schmitt (246) in 1930 reviewed the use of Derris elliptica as an insecticide. Dusting with the finely pulverized root was effective against flies.

Campbell and Sullivan (52) in 1933 reported Tephrosia latidens from Florida to be less effective than a sample of derris when tested as a kerosene extract against flies.

Gnadinger (117) in 1933 reviewed the literature on rotenone in fly sprays and cited unpublished work by Ginsburg, which indicates that the pyrethrins are more toxic than rotenone to flies.

A writer called "O. H." (128) in 1933 stated that it was possible to use a derris root extract in place of arsenic in the preparation of fly paper.

Spoon (257) in 1933 reported tests of rotenone as an insecticide in Holland and stated that rotenone appeared to have no value against full-grown flies.

Worsley (326) in 1934 reported that against flies tephrosin had been found to be as effective as pyrethrum provided the insects were actually hit with it; pyrethrum, however, had a temporary repellent effect for a short time after spraying, a property which tephrosin does not possess.

Pearson (228) in 1935 reported on the role of pine oil in cattle-fly sprays. Tests were made with a commercial pine-oil extract of derris

containing 5 percent of rotenone and with "Yarmor" pine oil containing 2 percent of pure rotenone. Both the knock-down and the mortality produced by derris extract are increased by pine oil. The rate of activation is greater than with pyrethrum. Combinations of derris and pine oil exhibit the same rate of kill as derris alone, significant mortality occurring after 24 hours. When combined with derris extract, high-grade pine oils are more effective than those of low grade. The differences are not so distinct, however, as with pyrethrum. The effect of pine oil on the toxicity of rotenone and of derris extract is similar. Pine oil increases the repellence of derris extract in relation to the quantity added, but not at so great a rate as that of pyrethrum extract.

Feytaud and Lapparent (87) in 1936 published the following formula for a fly spray: Cube powder or derris powder 10 gm. and pyrethrum powder 10 gm. is macerated in 100 gm. of a mixture of equal parts of terpinolene and orthodichlorobenzene or carbon tetrachloride for 5 days with frequent agitation, then filtered and a perfume added, for example, 10 percent of "terpene de citronelle."

R. J. Prentiss and Company, in advertising literature published in 1936, discussed laboratory and field methods of evaluating stock sprays. The following factors were considered: Physical, physiological, and toxic properties by the Peet-Grady test, and repellent properties. This company manufactures "Prentox Stock Spray Concentrate No. 20" and "Prentox L. S. Concentrate," both of which contain derris extractives. A proper combination of derris resins with a safe and effective repellent of the fumigant type dissolved in a properly chosen base oil will make a stock spray that will fully meet the most exacting specifications.

Boyd (37) in 1937 reviewed the use of rotenone in control of household insects. Rotenone as a fly spray and combinations of rotenone with pyrethrum and with thiocyanates were referred to.

Greenup (126), American Commercial Attaché at Lima, Peru, in 1937 advised that Cubex, a proprietary insecticide made from Cube, was used only as a general household insecticide for killing flies and other insects.

Hardtmann (137) in 1937 recommended oil-rotenone sprays for combating flies and gnats. (See Hardtmann under Hypoderma, page 68 .)

Dibble and Muncie (74) in 1938 recommended derris in control preparations and fly killers for livestock pests. Derris is slower acting than pyrethrum but does not deteriorate so rapidly in sun and air. Dusts should contain from 0.5 to 1.0 percent of rotenone.

Thomssen and Doner (274) in 1938 reviewed published information on fly control for livestock and mentioned rotenone sprays for killing adult flies.

The Wisconsin Agricultural Experiment Station (323) in 1938 reported that the best spray for protecting cattle against flies contained 5 percent of pyrethrum extract in a highly refined mineral-seal oil of viscosity 40 to 50. Among the materials that proved ineffective as a fly spray insecticide in these tests were rotenone and other derris extractives, sulfur compounds, and a number of synthetic insecticides. Several antioxidants, tested to learn whether they would prolong the effectiveness of insecticides, failed to improve cattle-fly sprays.

According to the manufacturers, Dodge and Olcott Company, New York, N. Y., in advertising literature published in 1939, Rotopyressenol No. 20 is a combination which "embodies in scientifically correct proportions the quick knock-down value of pyrethrum and the high moribund kill and leg paralysis of dihydrorotenone, both enhanced by the activative penetration of Essenol." D. and O. Essenol is said to be an insecticidally active combination of essential oils, and it is stated that the effective killing power of pyrethrum and rotenone sprays is substantially increased by its addition.

Whitmire (318) in 1939 defined moribund flies as "those that can move some part of their bodies, but cannot fly or walk to an extent to enable them to get off the observation paper." He described an apparatus and method for determining moribund kill. Rotenone and certain derivatives of it (e.g., dihydrorotenone) in fly sprays do not kill flies immediately but act slowly, producing moribund flies.

In 1940 the Experimental and Research Station, Cheshunt, Herts, England (81), reported that applications of pyrethrum powder to mushroom beds had given results [against Diptera] as good as those obtained by atomization of pyrethrum and derris extracts with apparatus employed in the treatment of warehouses.

An anonymous writer (8) in 1941 reported that the name "Indalone" had been registered by U. S. Industrial Chemicals, Inc., New York, N. Y., as the trade-mark of the solvent alpha, alpha-dimethyl-alpha'-carbobutoxy-gamma-dihydropyrone. Indalone, formerly marketed under the name "dihydro-pyrone," was developed for use in liquid contact insecticides as a solvent for derris-root extractives. When used in this way it has the property of increasing the insecticidal effectiveness of the ingredients dissolved in it andof holding derris extractives in solution in the commonly used base oils. Indalone is a powerful insectifuge and repels the common winged insects, to which it appears to have an obnoxious taste. Because of this high repellency, it is especially suitable for cattle sprays and mosquito lotions.

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